Advanced Software Engineering
(CS6401)

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Software Life Cycle Models
(Lecture-3)

Topics covered in Previous Lectures:

- Nature of software
- Nature of software projects
- What is Software Engineering?
- Programs vs. Software Products
- Software Process
- Introduction to Life Cycle Models

Software Life Cycle Models

- Let us review the main steps
  - Problem Definition (define the problem)
  - Feasibility study (establish **cost effectiveness** of the solution we proposed to)
  - Analysis (try to clearly define **the responsibility or functions** that the software must undertake)
  - System Design
  - Detailed Design
  - Implementation or Coding
  - Maintenance

Software Life Cycle Models

- A separate planning step for large applications may be introduced after feasibility (or part of feasibility)

- Study the outputs of the steps

Problem Definition

- To answer: What is the Problem?
- Where and by whom is the problem felt?
  - Where in the organization particularly the problem has been felt
- Meet users and management and obtain their agreement that there is a problem

Problem Definition

- If problem exists, and it need to be resolved
  - It becomes a project
  - Commitment of funds implied

The objective is to clearly define goal for the project and establish as a project

Problem Definition

- Prepares a brief statement of problem (small document not extensive but important, it is the first deliverable)
  - Avoids misunderstandings
  - Get concurrence from user/management
  - Usually short: 1 or 2 pages

- Estimate cost and schedule for the next feasibility step

Problem Definition

- Estimate roughly overall project cost to give users a sense of project scope. The estimates become more refined in later steps.
  - misconception by the user that the project will be done with the cost in his mind
  - roughly estimated cost is acceptable by the user
  - it is preliminary and based on the experience of analyst or computer experts

Problem Definition

- This step is short; lasts a day or two
  - do not involve cost and we just invite an expert from the development industry to make him understand the problem and give a scope
- Proper understanding and characterization of problem essential
  - To discover cause of the problem
  - To plan directed investigation
  - Else, success is unlikely (end up solving a wrong problem and user may not accept)

Problem Definition

- Possible initial characterization of problems
  - Existing system has poor response time, i.e., user is unable to process a transaction or take too large time.
  - Unable to handle workload (so many transactions or users making transactions at same time and long queue of users)
  - Problem of cost: existing system uneconomical
  - Problem of accuracy and reliability
  - Requisite information is not produced by system
  - Problem of security

Ex: Railways Reservation System

Problem Definition Document

- Short document called problem statement document
  - **Project Title**
  - **Problem Statement**: Concise statement of problem, possibly in a few lines
  - **Project Objectives**: state objective of the project defined for the problem
  - **Preliminary Ideas discussion with the user or past experience**: possible solutions, if any, occurring to user and/or analyst could be stated here
  - **Project Scope:** give overall cost estimate as rough figure
  - **Feasibility Study:** indicate time and cost for the next step

Problem Definition Document

<u>Note:</u>

- Do not confuse between problems and solutions e.g., ‘develop computerized payroll’ cannot be a problem
- No commitment is implied to preliminary ideas (may explore many ideas during analysis)

Feasibility Study

- To get better understanding of problems and reasons by studying existing system, if available
  - Are there feasible solutions?
  - Is the problem worth solving?
- Consider different alternatives
- Estimate costs and benefits for each alternative
- Essentially covers other steps of methodology (analysis, design, etc.) in a capsule form

Feasibility Study

- Make a formal report and present it to management and users; review here confirms the following:
  - Will alternatives be acceptable
  - Are we solving the right problem
  - Does any solution promise a significant return (because investing on the project)
- Users/management select an alternative
- Many projects ‘die’ here (alternatives are not acceptable or too high cost)

Types of Feasibility

- **Economical**
  - will returns justify the investment in the project?
- **Technical**
  - is technology available to implement the alternative?
- **Operational**
  - will it be operationally feasible of the solution as per rules, regulations, laws, organization culture, union agreements, etc.?

Costs

- One-time(initial) costs include equipment, training, software development, consultation, site preparation

- Recurring costs include salaries, supplies, maintenance, rentals, depreciation (finally there will be replacement cost)

- Fixed and variable costs; vary with volume of workload

Benefits

- Benefits could be tangible (i.e., quantifiable) or intangible (which can not be measured)

- Saving (tangible benefits) could include
  - saving in salaries
  - saving in material or inventory costs
  - more production
  - Reduction in operational costs, etc.

Benefits

- Intangible benefits may include
  - Improved customer service
  - Improved resource utilization
  - Better control over activities (such as production, inventory, finances, etc.)
  - Reduction in errors
  - Ability to handle more workload

Estimating Costs

- How to estimate costs so early in the project?
  - Decompose the system and estimate costs of components; this is easier and more accurate then directly estimating cost for the whole system
    - computer cost or networking cost which is separate from the software development cost
  - Use historical data whenever available

Estimating Costs (cont..)

- Use organizations standards for computing overhead

- costs (managerial/secretarial support, space, electricity, etc)

- Personal (for development and operations) costs are function of time, hence estimate time first

Financial Analysis

- Consider time-value of money; while investment is today, benefits are in future

- Compute present value P for future benefit F by

  $P = F/(1+L)^n$ where L is the prevailing interest rate and n is year of benefit

- Take into account life of system: most systems have life of 5-7 years of course this is also less because of technology advancements

Financial Analysis

- Cost is ‘investment’ in the project, benefits represent ‘return’
- Compute payback period in which we recover initial investment through accumulated benefits
- Payback period is expected to be less than system life.

Feasibility study report

- Introduction
  - A brief statement of the problem, the environment in which the system is to be implemented, and constraints that affect the project (cost, effort, available resources)
- Management Summary and Recommendations
  - Important findings and recommendations

Feasibility study report

- Alternatives:
  - A presentation of alternative system specifications; criteria that were used in selecting the final approach
- System Description
  - An abbreviated version of information contained in the System-Specification or reference to the specifications

Feasibility study report

- Cost-Benefit Analysis
- Evaluation of Technical Risk
- Legal Ramification (if any)
  - Once the estimation is accepted by the user/management then the clear signal for the go-ahead with the project

Requirement Analysis

- Objective: determine what the system must do to solve the problem (without describing how)

- Done by Analyst (also called Requirements Analyst)

- Produce Software Requirement Specifications (SRS) document

- Incorrect, incomplete, inconsistent, ambiguous SRS often cause for project failures and disputes

Requirement Analysis

- A very challenging task
  - Users may not know exactly what is needed or how computers can bring further value to what is being done today
  - Users change their mind over time
  - They may have conflicting demands
  - They can’t differentiate between what is possible and cost-effective against that is impractical (wish-list)
  - Analyst has no or limited domain knowledge
  - Often client is different from the users

SRS

- SRS is basis for subsequent design an implementation

- First and most important baseline
  - Defines contract with users
  - Basis for validation and acceptance

- Cost increases rapidly after this step; defects not captured here become 2 to 25 times more costly to remove later (defects which entered in the design and implementation which will be more costlier to remove it)

SRS

- It identifies all functional (inputs, outputs, processing) and performance requirements, and also other important constraints (legal, social, operational)

SRS

- Should be adequately detailed so that
  - Users can visualize what they will get
  - Design and implementation can be carried out

- Covers what and what at business level; e.g.,
  - What calculate take-home pay
  - How: procedure (allowances, deductions, taxes etc.)

Analysis Process

- Interviewing clients and users essential to understand their needs from the system

- Often existing documents and current mode of operations can be studied (they may have documents explaining procedures)

Analysis Process

- Long process: needs to be organized systematically
  - Interviewing, correlating, Identifying gaps, and iterating again for more details
  - Focus on what gets done or needs to be done
  - Focus on business entities, their interactions, business events, …

- Identify users and important business entities

- Get functional (domain) knowledge

Analysis Process

- Interview users or get details through questionnaires
- Examine existing system:
  - Study existing forms, outputs, records kept (files, ledgers, computerized systems)
- Often goes outside in:
  - what outputs needed, which inputs provide data, what processing done, what records kept, how records updated (i.e., go inwards from system boundaries)

Interviews

- Identify users, their roles and plan interviews in proper order to collect details progressively and systematically

- Conducting interviews is an art
  - Workout scope, durations, purpose
  - Keep records and verify/confirm details it with the user
  - Needs to sometimes ‘prompt’ users in visualizing requirements

- Need good communication skills, domain knowledge, patience, etc

Organizing Findings

- Massive amount of information is collected from interviews, study of existing systems
- Need to be organized, recorded, classified and conceptualized (at multiple level of details)
- Tools/repositories available (describe inputs, outputs, files, computations, usages, functions):
  - Help in checking consistency and completeness of the work done so far

Organizing Findings

- Create models or projections from different perspectives (in order to systematically organize the idea found out from the process)
  - Way to handle complexity (divide-and-conquer)
  - Hide unnecessary details (focus on certain specific aspects and hide unnecessary data)
- Reduces errors, ensures consistency/completeness

- Data-flow diagrams (for processing) - what data is being used in which step, entity-relationship models (for data domain) and object models commonly used

System Design (address 'how part')

- Objective: To formulate alternatives about how the problem should be solved
- Input is SRS from previous step
- Consider several technical alternatives based on type of technology, automation boundaries, type of solutions (batch/on-line), including make or buy (Before business alternatives now here technical alternatives)
- Propose a range of alternatives: low-cost, medium cost and comprehensive high cost solutions

Alternatives

- For each alternatives, prepare high-level system design (in terms of architecture, DB design, …); prepare implementation schedule, carry out cost-benefit analysis

Alternatives

- Prepare for technical (ensure different technological alternatives considered are meaningful) and management review (ensure that we are within the proposed cost and able to meet the schedule)
  - Costs rise sharply hereafter
  - Costs can be quantified better at this stage
  - Technical review uncovers errors, checks consistency, completeness, alternatives
- Phase ends with a clear choice which can be further taken into design and implementation phase.

Design Goals

- Processing component: main alternatives
  - Hierarchical modular structure in functional approach (conventional methodology)
  - Object-oriented model and implementation

- Different design methodologies for functional and Object Oriented

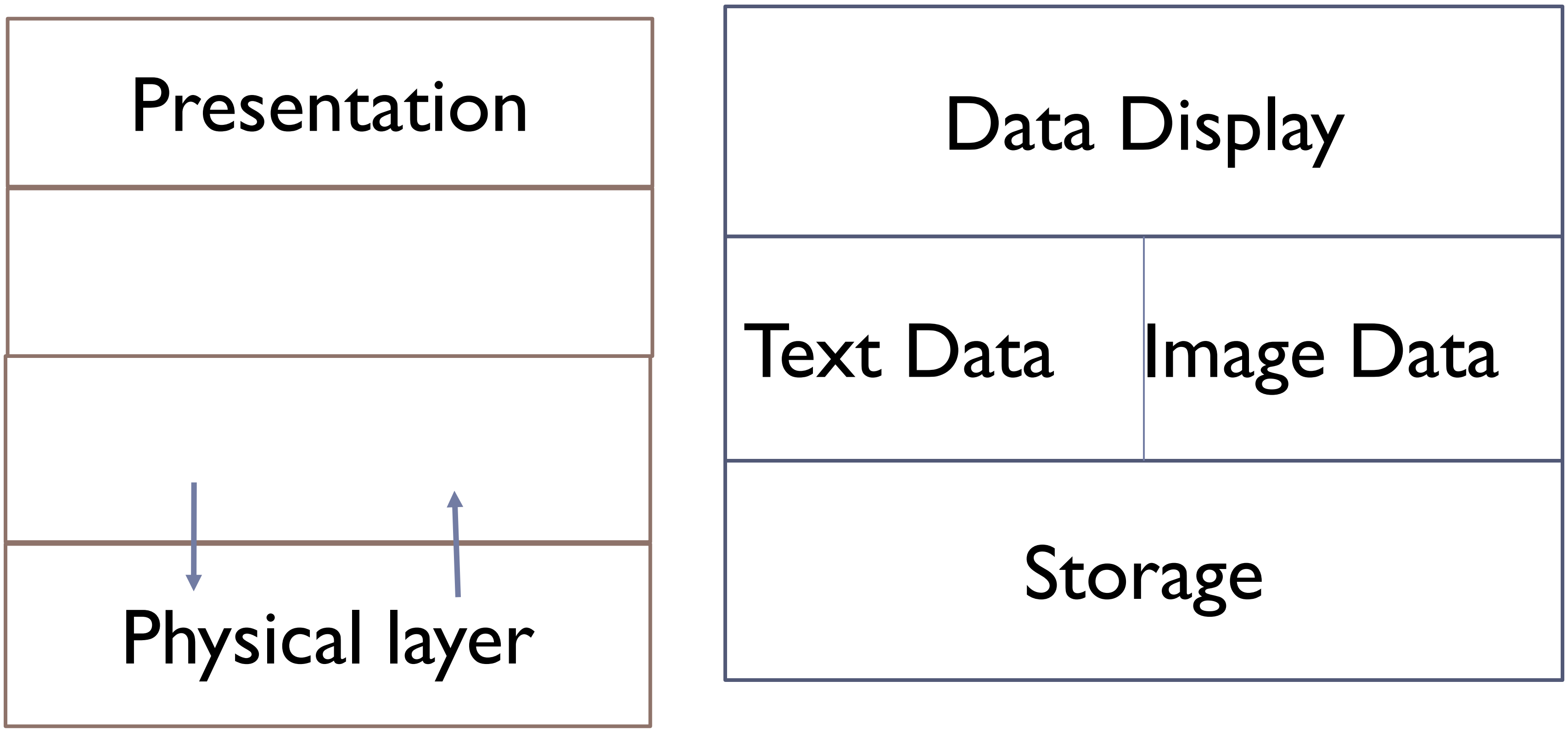
Design Goals

- Data component
  - Normalized data base design using ER model (conceptual design)
  - De-normalization for performance (modify the conceptual normalized data into the data base design to improve the performance)
  - Physical design: Indexes (choosing right storage technique through which data can be accessed efficiently)
    - Design of software consisting of designing the processing component and data component. They may be designed separately or they may merge into single design dimension when we use object oriented

System Architecture

- Decompose a complex system:
  - Partitions (vertical)
  - Layers (horizontal)
- Each layer and partition is given specific responsibility
- Define subsystems/modules as building blocks
  - Each module has a specific function to perform (piece of code)
  - Modules together may make a subsystem
  - Multiple such subsystems make up a overall system
  - subsystem may be representing a partition or layer
- Modules make calls on each other
  - Pass data, obtain results

System Architecture

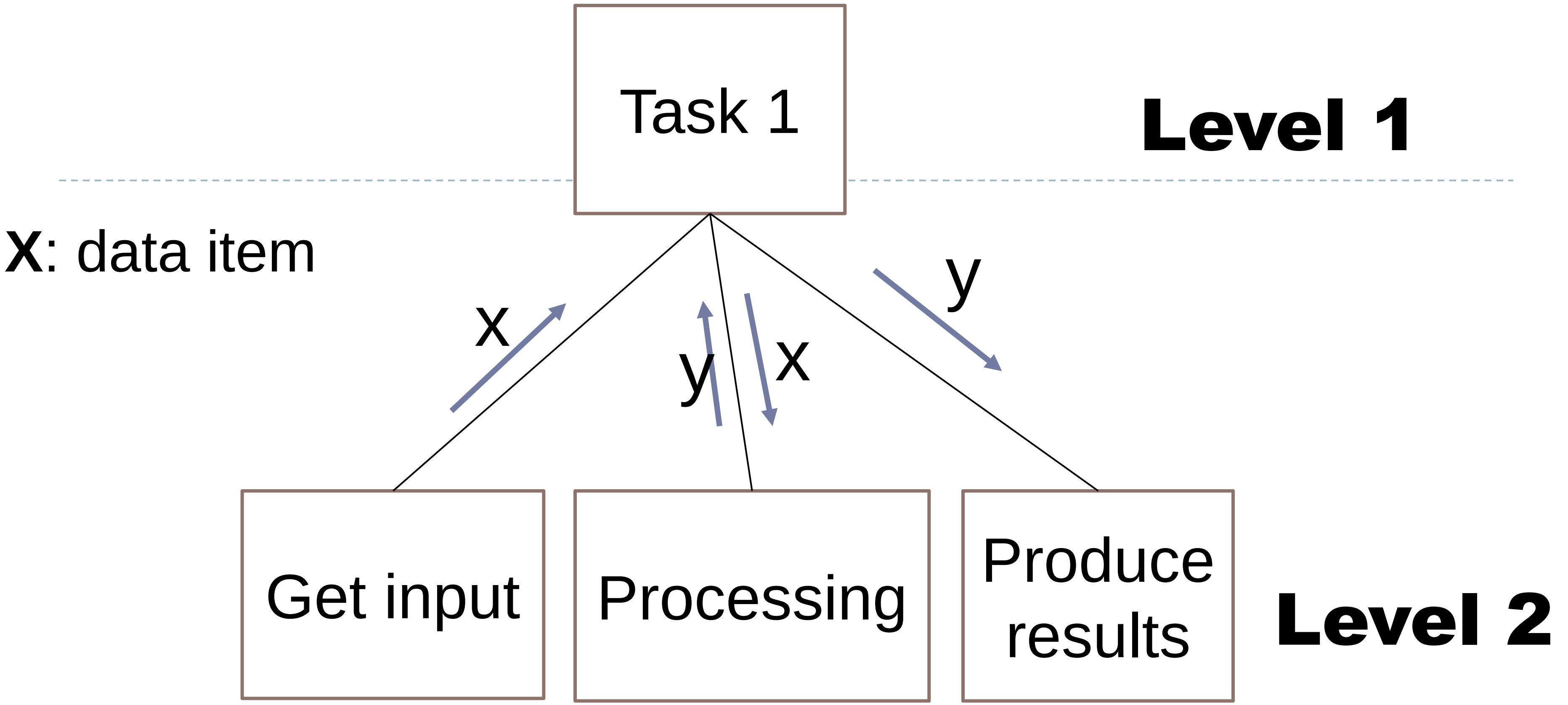


System Architecture

- Maximize module independence and minimize module interdependence (from maintenance point of view and complex system)
  - Cohesion and coupling characteristics
  - Essential for maintenance (a module can be replaced with an equivalent module without disturbing overall functioning)

Structure Chart Notation

- Software Architecture can be defined in terms of modules and their interactions can be captured through a Diagram Notation tool called Structure Chart
- Used in functional methodology to depict modules and their calling relationships
- Techniques are available to go from DFD to structure charts
- Hierarchical structure: module at level i calls modules at level i+1; control flow not shown

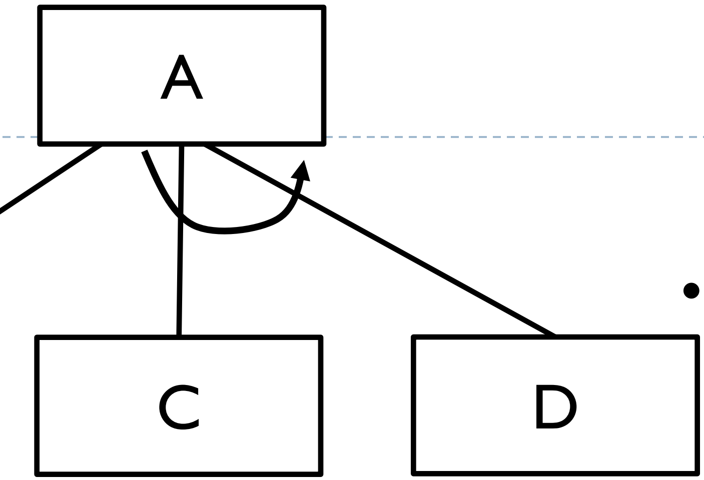


- **Lines** representing the calls that the module Task1 makes to Get input/Processing/Produce results in order to perform its own job
- Modules on level 2 can be decomposed further

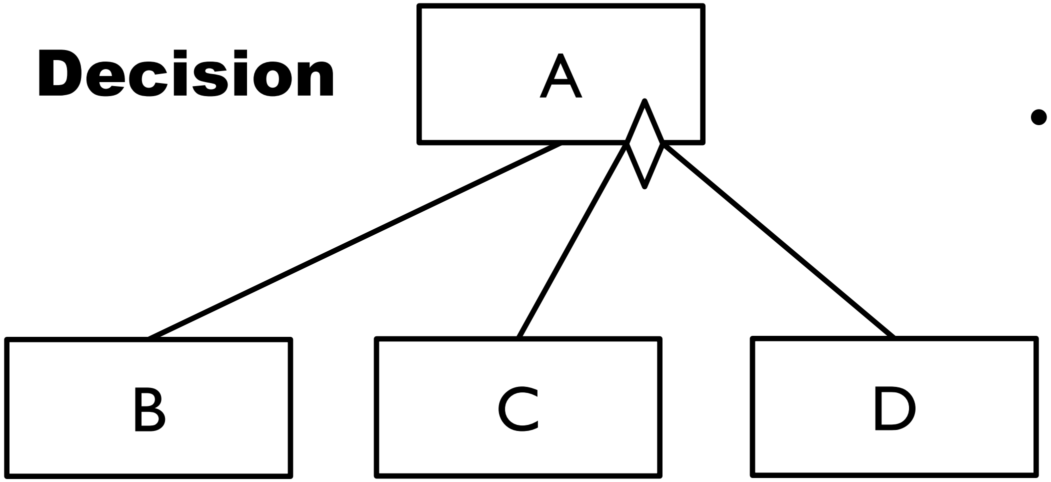
Structure Chart …

- Modules at higher levels generally do coordination and control; modules at lower levels do i/o and computations
- Structure chart may show important data passing between modules, and also show main iterations and decision-making without much details

Iteration



Decision



- Module A calls C and D module repeatedly, however, the details of how often the iteration would be done are not given on the structure chart
- It only shows a such a iteration or decision exists in the software

OO Approach

- Design consists of classes
  - Have structure (properties)
  - Have behavior (methods/operations)
  - Inheritance major feature in OO for re-use
- Data and executable functions associated with the class (these are called structure and behavior for the class)
- This is a paradigm that combines data and processing together on a single dimension and identifies classes which have structural properties and behavioral methods defined for them

OO Approach

- Class diagrams show static structure of the system
- Interaction diagrams are used to capture dynamic behavior of classes and objects
- Large systems decomposed into packages

Design Document Format

- Introduction
- Problem Specification: include here the data-flow diagrams, entry-relationship diagrams or class diagrams
- Software structure: give the high-level software structure chart identifying major modules and major data elements in their interfaces

Design Document Format

- Data Definitions: for major data structure, files and database
- Module Specifications: Indicate inputs, outputs, purpose and subordinates modules for each software modules
- Requirements Tracing: Indicates which modules meet which requirements

Design document format…

- This document will be reviewed by the technical people and ensured that this document is comprehensive
- Ensures that it covers all the functions identified in the SRS document

Detailed Design

- Specific implementation alternative already selected in previous step giving
  - Overall software structure
  - Modules to be coded
  - Database/file design
- In this step, each component is defined further for implementation

Detailed Design…

- Deliverables include
  - Program Specifications (e.g. pseudo-code)
  - File design (organization, access method…)
  - Hardware specifications (as applicable)
  - Test plans
  - Implementation schedule
- Ends in technical review

Implementation Phase

- Programs are coded, debugged and documented
- Initial creation of data files and their verification (manual existing data is converted to the data files and database)
- Individual modules as well as whole system is tested
- Operating procedures are designed
- User does acceptance of the system
- System is installed and switch-over affected

Operations and Maintenance

- Systems must continue to serve user needs correctly and continuously
- Maintenance activities consist of
  - Removing errors
  - Extending present functions
  - Adding new functions
  - Porting to new platforms (occasionally it may be)

Summary

- Each phase has a well defined task and a deliverable
- Feasibility establishes alternatives and carries out cost-benefit analysis
- Requirements analysis is very challenging and SRS forms the first baseline
- Design step consists of architecture, database and interface design

Summary

- Adherence to a software life cycle model:
  - helps to do various development activities in a systematic and disciplined manner.
  - also makes it easier to manage a software development effort.

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