CMSC 435: Software Engineering Section 0101

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- Course page
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Back to Software

- Software uses some of the most complex structures ever designed
- Need to apply/develop engineering principles to/for software
- Software engineering is concerned with theories, methods and tools for professional software development

Important: Team Work

- Most software is developed
  - By teams of
    - Designers
    - Programmers
    - Managers
- Social skills
  - Trust other team members
    - They will develop software components that you may use
- Management skills
  - Schedules
  - Work distribution
  - Budget

A Few Facts About Software Today

- Software costs often dominate system costs.
  - The costs of software are often greater than the hardware cost
- Software costs more to maintain than it does to develop.
  - For systems with a long life, maintenance costs may be several times development costs

Costs Involved

- Typically
  - 60% of costs are development costs,
  - 40% are testing costs.
  - For custom software, evolution costs often exceed development costs
- Costs vary depending on the type of system being developed and the requirements of system attributes such as performance and system reliability
- Distribution of costs depends on the development method that is used

We will Engineer Software

- But what is software?
  - Computer programs and
  - Associated documentation
- Software products may be developed for
  - A particular customer or
  - A general market

Role of a Software Engineer

- Software engineers should adopt a systematic and organised approach to their work and use appropriate tools and techniques depending on the problem to be solved, the development constraints and the resources available

Attributes of Good Software

- Should deliver the required functionality and performance
- Maintainability
  - Software must evolve to meet changing needs
- Dependability
  - Software must be trustworthy
- Efficiency
  - Software should not make wasteful use of system resources
- Usability
  - Software must be usable by the users for which it was designed

Software Processes

- What is a Software Process?
  - A set of activities whose goal is the development or evolution of software
- Some Activities:
  - Specification
    - what the system should do and its development constraints
  - Development
    - production of the software system
  - Validation
    - checking that the software is what the customer wants
  - Evolution
    - changing the software in response to changing demands

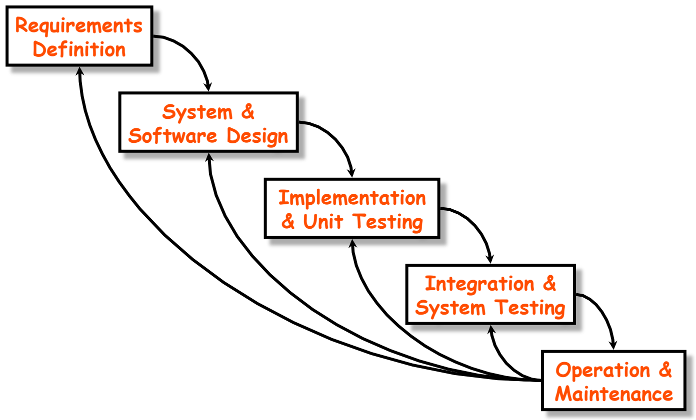
Software Process Models

- A simplified representation of a software process, presented from a specific perspective
- Examples of process perspectives are
  - Workflow perspective
    - sequence of activities
  - Data-flow perspective
    - information flow
  - Role/action perspective
    - who does what
- Generic process models
  - Waterfall
  - Evolutionary development
  - Formal transformation
  - Integration from reusable components

Generic Software Process Models

- The waterfall model
  - Separate and distinct phases of specification and development
- Evolutionary development
  - Specification and development are interleaved
- Formal systems development
  - A mathematical system model is formally transformed to an implementation
- Reuse-based development
  - The system is assembled from existing components

Waterfall Model



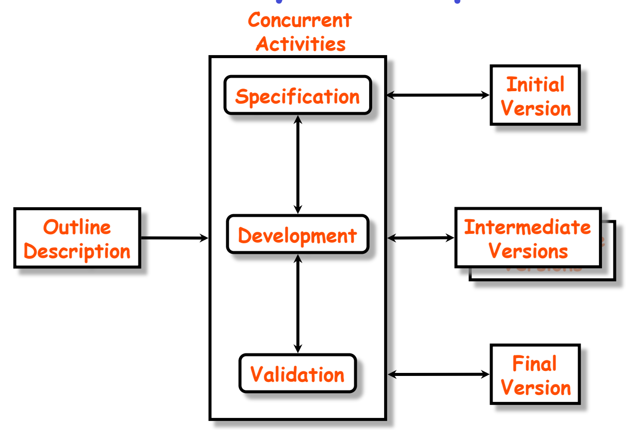
Waterfall Model Problems

- Inflexible partitioning of the project into distinct stages
- This makes it difficult to respond to changing customer requirements
- Therefore, this model is only appropriate when the requirements are well-understood

Evolutionary Development

- Exploratory development
  - Objective is to work with customers and to evolve a final system from an initial outline specification. Should start with well-understood requirements
- Throw-away prototyping
  - Objective is to understand the system requirements. Should start with poorly understood requirements

Evolutionary Development



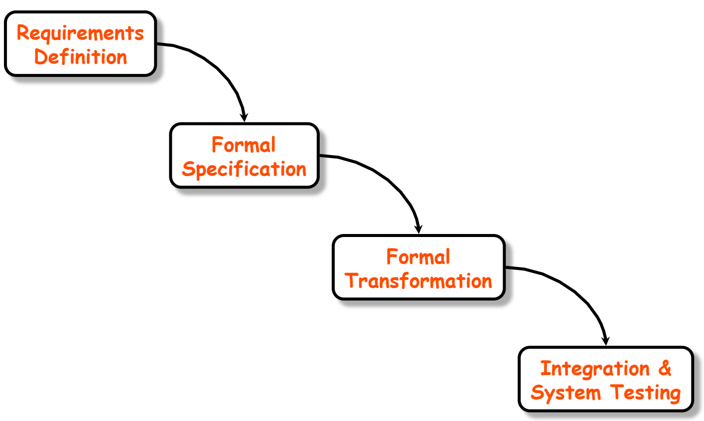
Evolutionary Development

- Problems
  - Lack of process visibility
  - Systems are often poorly structured
  - Special skills (e.g. in languages for rapid prototyping) may be required
- Applicability
  - For small or medium-size interactive systems
  - For parts of large systems (e.g. the user interface)
  - For short-lifetime systems

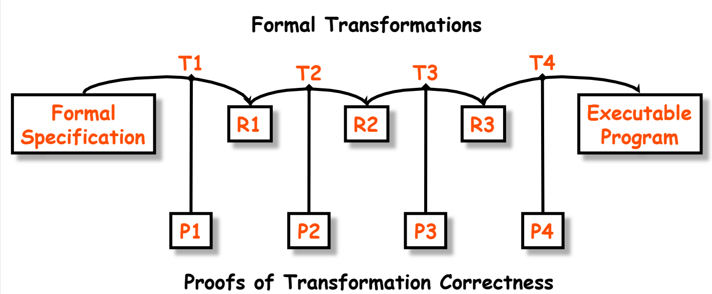
Formal Systems Development

- Based on the transformation of a mathematical specification through different representations to an executable program
- Transformations are 'correctness-preserving' so it is straightforward to show that the program conforms to its specification
- Embodied in the 'Cleanroom' approach to software development

Formal Systems Development



Formal Transformations



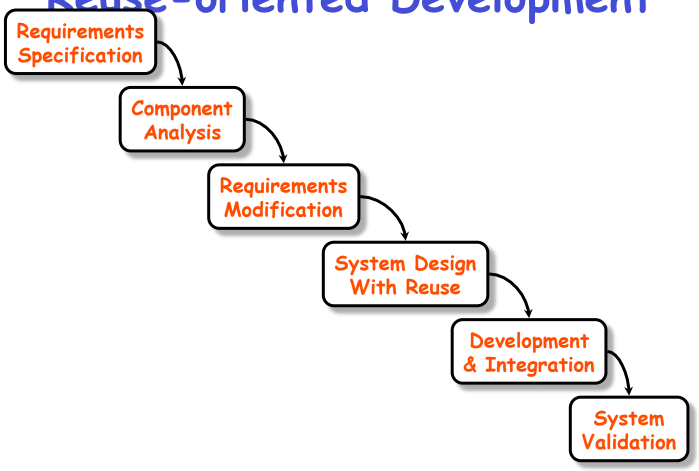
Formal Systems Development

- Problems
  - Need for specialised skills and training to apply the technique
  - Difficult to formally specify some aspects of the system such as the user interface
- Applicability
  - Critical systems especially those where a safety or security case must be made before the system is put into operation

Reuse-oriented Development

- Based on systematic reuse where systems are integrated from existing components or COTS (Commercial-off-the-shelf) systems
- Process stages
  - Component analysis
  - Requirements modification
  - System design with reuse
  - Development and integration
- This approach has received a lot of attention recently

Reuse-oriented Development



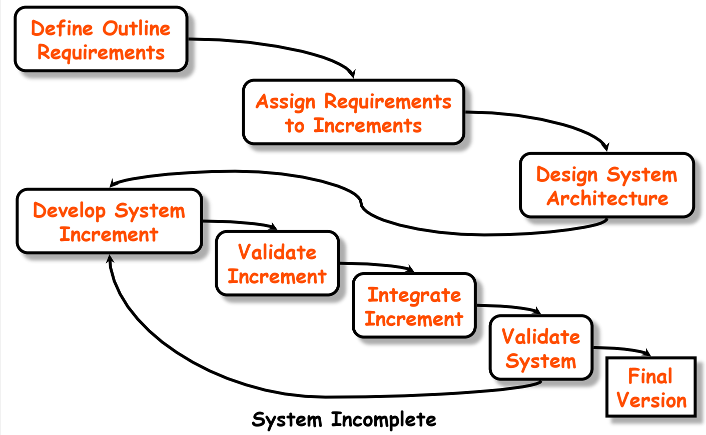
Process Iteration

- System requirements ALWAYS evolve in the course of a project so process iteration where earlier stages are reworked is always part of the process for large systems
- Iteration can be applied to any of the generic process models
- Two (related) approaches
  - Incremental development
  - Spiral development

Incremental Development

- Rather than deliver the system as a single delivery, the development and delivery is broken down into increments with each increment delivering part of the required functionality
- User requirements are prioritized and the highest priority requirements are included in early increments
- Once the development of an increment is started, the requirements are frozen though requirements for later increments can continue to evolve

Incremental Development



Incremental Development Advantages

- Customer value can be delivered with each increment so system functionality is available earlier
- Early increments act as a prototype to help elicit requirements for later increments
- Lower risk of overall project failure
- The highest priority system services tend to receive the most testing

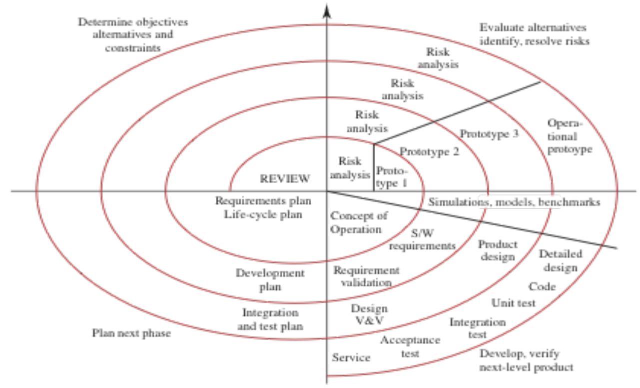
Extreme Programming

- New approach to development based on the development and delivery of very small increments of functionality
- Relies on constant code improvement, user involvement in the development team and pairwise programming

Spiral Development

- Process is represented as a spiral rather than as a sequence of activities with backtracking
- Each loop in the spiral represents a phase in the process.
- No fixed phases such as specification or design - loops in the spiral are chosen depending on what is required
- Risks are explicitly assessed and resolved throughout the process

Spiral Model of the Software Process



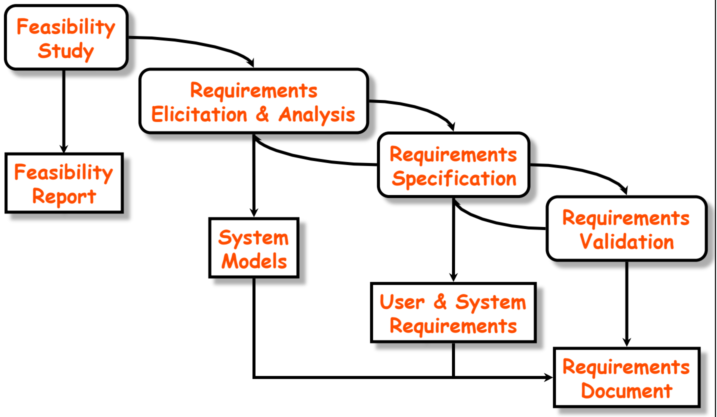
Spiral Model Sectors

- Objective setting
  - Specific objectives for the phase are identified
- Risk assessment and reduction
  - Risks are assessed and activities put in place to reduce the key risks
- Development and validation
  - A development model for the system is chosen which can be any of the generic models
- Planning
  - The project is reviewed and the next phase of the spiral is planned

Software Specification

- The process of establishing what services are required and the constraints on the system's operation and development

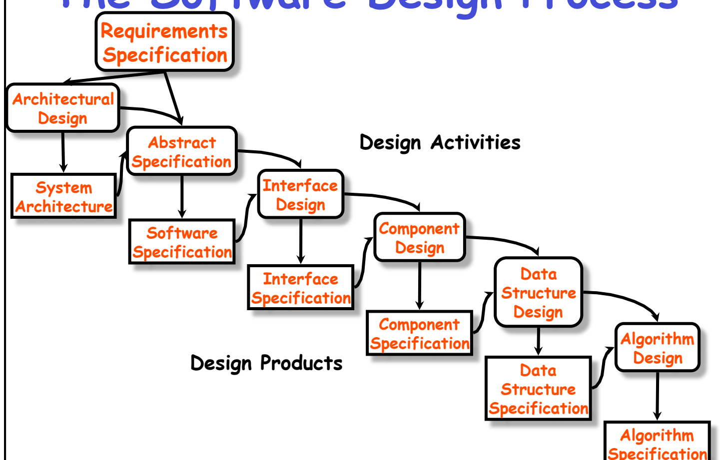
The Requirements Engineering Process



Software Design and Implementation

- The process of converting the system specification into an executable system
- Software design
  - Design a software structure that realises the specification
- Implementation
  - Translate this structure into an executable program
- The activities of design and implementation are closely related and may be inter-leaved

The Software Design Process



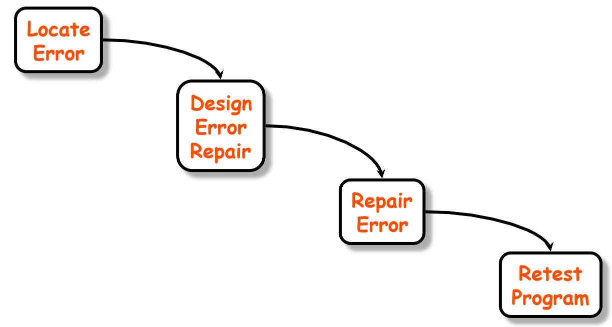
Design Methods

- Systematic approaches to developing a software design
- The design is usually documented as a set of graphical models
- Possible models
  - Data-flow model
  - Entity-relation-attribute model
  - Structural model
  - Object models

Programming and Debugging

- Translating a design into a program and removing errors from that program
- Programming is a personal activity - there is no generic programming process
- Programmers carry out some program testing to discover faults in the program and remove these faults in the debugging process

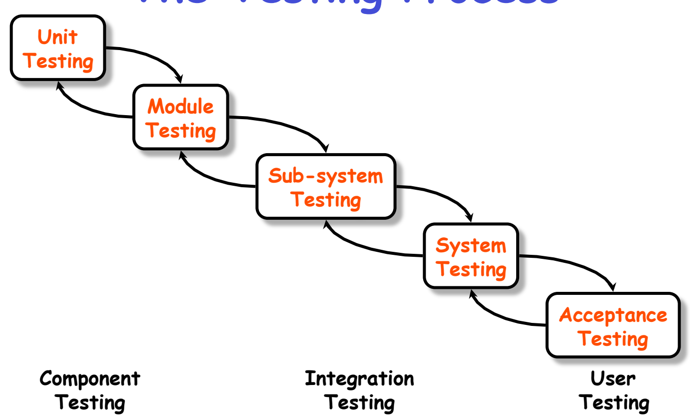
The Debugging Process



Software Validation

- Verification and validation is intended to show that a system conforms to its specification and meets the requirements of the system customer
- Involves checking and review processes and system testing
- System testing involves executing the system with test cases that are derived from the specification of the real data to be processed by the system

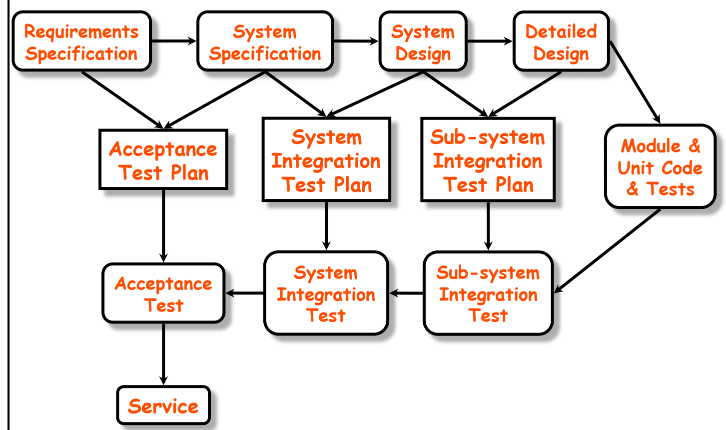
The Testing Process



Testing Stages

- Unit testing
  - Individual components are tested
- Module testing
  - Related collections of dependent components are tested
- Sub-system testing
  - Modules are integrated into sub-systems and tested. The focus here should be on interface testing
- System testing
  - Testing of the system as a whole. Testing of emergent properties
- Acceptance testing
  - Testing with customer data to check that it is acceptable

Testing Phases



Software Evolution

- Software is inherently flexible and can change.
- As requirements change through changing business circumstances, the software that supports the business must also evolve and change

System Evolution