Software Processes

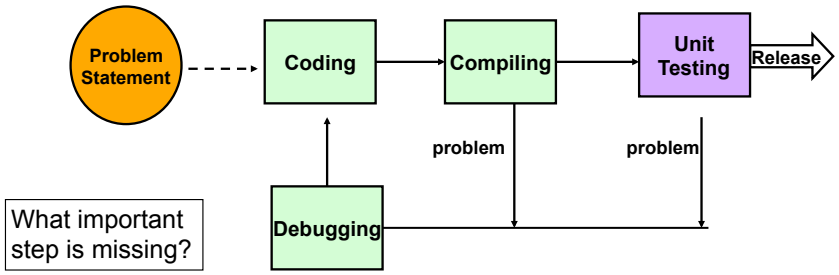
Chapter 2

What is a software process?

- It is a description of
  - what tasks need to be performed in
  - what sequence under
  - what conditions by
  - whom to

  achieve the "desired results."
- Desired results: high quality software product.
- Provides guidance for systematic coordination and controlling of tasks and personnel.

A simple process



- Suitable for student projects
- Problems when
  - some steps are skipped
  - problem statement is not well stated or understood

As projects get larger and more complex . . .

- We need more people and more coordination
  - Problem statement needs to be expanded and clarified (requirements/specifications)
  - Need a good, well-documented design
  - Need to make sure various developers can work together (tools, documentation)
  - Need to ensure adequate testing is done
- We need a more detailed process

A software process

- A structured set of activities used to develop a software system.
- Many different software processes but all involve these activities:
  - **Specification** – defining what the system should do (stating the requirements)
  - **Development** – defining the organization of the system (aka the design) and implementing the system
  - **Validation** – checking that the system does what the customer wants
  - **Evolution** – changing the system in response to customer needs.
- Different processes do the activities in different ways.

Software specification

- The process of establishing the requirements:
  - the features/functions that are required by the users
  - the constraints on the system's operation and development.
- Requirements engineering process
  - Requirements elicitation and analysis
    - What do the stakeholders require or expect from the system?
    - May observe existing systems, develop models or prototype
  - Requirements specification
    - Defining the requirements in detail and documenting them.
  - Requirements validation
    - Checking them for clarity, consistency, completeness, etc.

Software development:
design and implementation

- Converting the requirements into an executable system.
- Software design
  - Description of the structure of the software using various models, interfaces, algorithms, etc.
- Implementation
  - Translate the design into an executable program
- Design and implementation are closely related and often interleaved.

Design activities

- **Architectural design**: where you identify
  - the overall structure of the system,
  - the sub-components (different parts)
  - their relationships and
  - how they are distributed (on different machines)
- **Interface design**, where you precisely define the interfaces between system components (how they communicate) (so they can be developed independently).
- **Component design**, where you design each sub-component
- **Data structure design**, where you design the system data structures and how these will be represented in storage.

Software validation

- Verification and validation (V & V) is intended to
  - show that a system conforms to its specification and
  - meets the needs of the system customer.
- Program testing:
  - executing the system over simulated data, ensuring the results are correct.
- Inspections and reviews:
  - humans analyze models and source code looking for errors or problems

Software evolution

- After the software has been released, it must be kept up to date.
  - Customers require new functions
  - Defects must be repaired
  - Must adapt to new platforms and machines
- Activities include:
  - Modifying requirements/specifications (as needed)
  - Modifying design (as needed)
  - Modifying the implementation
  - Retesting, adding new test cases.

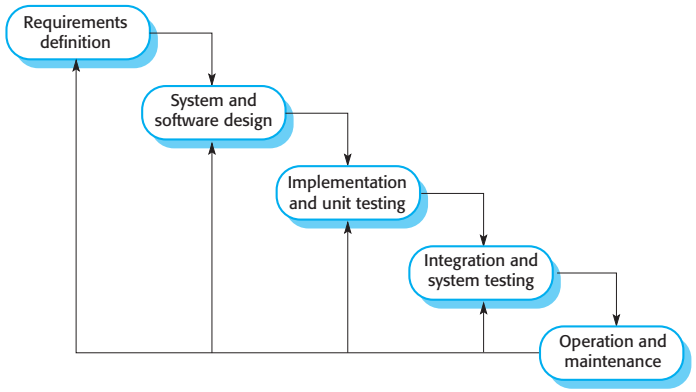
Software process models
(or frameworks, or paradigms)

- A software process model:
  - is a simplified representation of a set of specific software processes.
  - must be “extended” with more detail to become an actual software process.
- Traditional software process models:
  - Waterfall model
  - Incremental development
  - Spiral model
  - Reuse-oriented software engineering

Waterfall model

- The waterfall model
  - One of the earliest publicized model
  - Separate and distinct phases are performed in sequence.
  - Planning occurs upfront: “Plan-driven”
- The separate phases:
  - Requirements definition
  - Software design
  - Implementation
  - Testing
  - (Maintenance)
- The output of one stage is input to the next.
- Tends to require/generate much documentation.

Waterfall model



What makes it go backwards?

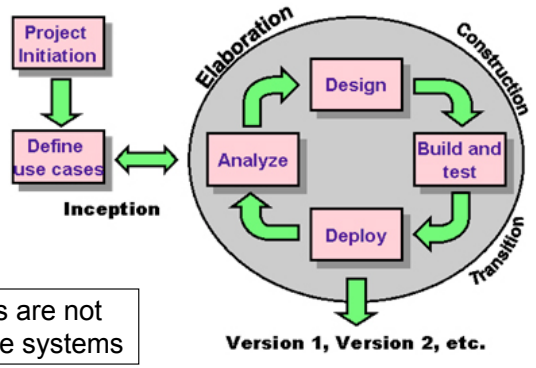
Waterfall model issues

- Good features:
  - Simple and easy to implement (better than no process)
  - Easy for managers to track the progress of the project
- Can be used for large projects when a system is developed at several sites.
  - Plan-driven nature of the this model helps coordinate the work.
- Main drawback: The difficulty of accommodating changes after the process is underway.
  - Change requires "backtracking": revising previous step(s), re-work (costly)
  - This model is appropriate only when
    a) the requirements are well-understood and
    b) changes will be fairly limited during the design process.
- Customers often need to change the requirements

Incremental development

- Specification, development and validation are interleaved in cycles.
- The system is developed as a series of versions or releases (called increments).
  - Each version adds functionality to the previous version.
  - Only the final version is a complete system.
- Each version is exposed to the user for feedback
  - The customer may come to the developers' site for demos/testing.
  - If the intermediate versions are given to the customer, it is called **Incremental Delivery**.
- Early versions can implement the most important, urgent, or risky features

Incremental development



Versions are not complete systems

Feedback from use of each version is incorporated into next Analyze phase

Incremental development benefits

- The cost of accommodating changing customer requirements is reduced.
  - Early versions are incomplete, so less re-work to do.
  - May require no changes to current version (add to future version).
- It is easier to get customer feedback on the work that has already been done.
  - Users understand a working incremental release better than documents from the specification or design phase.
- Can be plan-driven (all versions planned ahead) OR plan each increment as it is encountered.

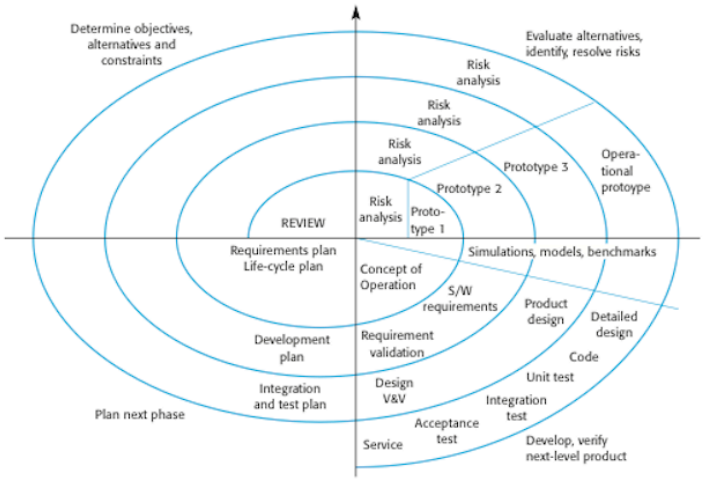
Incremental development problems

- The process is not visible
  - there's less process documentation, so it's difficult to measure progress.
  - may not know how many more increments are required.
- Difficult to design and implement common facilities needed by all versions
- System structure tends to degrade as new increments are added.
  - this makes the code more difficult to modify each time.
  - UNLESS time and money are spent on **refactoring** to improve the software.
  - **Refactoring**: disciplined technique for restructuring an existing body of code, altering its internal structure without changing its external behavior.
  - Modifying a program to improve its structure, reduce its complexity, or make it easier to understand.

Spiral model

- Proposed by Barry Boehm in 1988.
- Process represented as a spiral
  - Each loop represents a phase in the process.
  - Content of each phase is not predetermined, plan as you go.
- Risks are explicitly assessed and resolved.
  - Assumes need for change are a result of project risks.
- Sectors of the model:
  - Identify objectives, alternatives and constraints.
  - Evaluate and reduce risk (may develop prototype).
  - Development and validation
  - Plan next phase (after review of current phase).

Figure 2.11 Boehm's spiral model of the software process



Spiral model issues

- Good for high-risk projects.
  - Often used in combination with other process models.
- In practice, the model is rarely used as published.
- Somewhat similar to incremental development, but
  - Risk assessment is incorporated into the process
  - Development is not required to be incremental:
    - prototypes and results of previous loops can be discarded.
    - production development could be postponed until the last loop.

Reuse-oriented software engineering

- The system is assembled from existing components.
- Components may be in the form of
  - source code that must be compiled into the final product OR
  - already compiled code that can be accessed from other programs.
- Process stages:
  - Requirements specification (similar to other process models)
  - Component analysis: search for close matches to requirements
  - Requirements modification: to reflect available components
  - System design with reuse: organize framework around acceptable components (may require designing new code).
  - Development and integration: components are integrated along with new code
  - System validation (similar to other process models)

Types of software components for reuse

- Web services
  - Various “functions” available for remote invocation from web apps or clients
  - Example: Google maps, Amazon web services
- Library of Classes: framework
  - Developed as a package to be integrated (compiled) with a component framework such as .NET or J2EE.
  - Example: parsekit for Mac OS X apps (scanners/parsers)
- Stand-alone software systems that are configured for use in a particular environment.
  - often called COTS: “Commercial off the Shelf” systems
  - Example: PeopleSoft, HR management for companies

Advantages and Disadvantages of Reuse-oriented Software Engineering

- Benefits
  - Reduces costs and risks (less code to write, already tested)
  - Usually leads to faster delivery.
- Disadvantages
  - Requirements may have to be compromised (no good matches found)
  - Control over evolution of system is lost (dependent on developers of the components).

2.3 Coping with change

- Change is inevitable in all large software projects.
  - Changing business environments lead to changing requirements
    - New opportunities and technologies
    - Changing markets, new competitors
  - New technologies open up new possibilities for improving implementations
  - New platforms require application changes
- Change leads to rework:
  - new requirements lead to more requirements analysis
  - this may lead to redesign of the system or components
  - this may lead to changes to the implementation
  - this may lead to new tests, and re-testing the system

Reducing the costs of rework: two approaches

- **Change avoidance:** include process activities that anticipate possible changes before significant rework is required.
  - i.e. develop a prototype to show some key features of the system to users, let them refine requirements before committing to them.
- **Change tolerance:** design the process to accommodate change at low cost
  - Use incremental development, get feedback from users.
  - Changes likely apply to most recent increment only, OR
  - Can be incorporated into later increments.

Software prototyping

- Prototype: an initial, incomplete, version of a system used to demonstrate concepts and try out options.
- Allows users to see how well system could support their work
- May lead to new ideas for requirements
- As prototype is developed, may reveal errors and omissions in the requirements
- Can check feasibility of design
  - For a database, make sure it efficient for most common queries
  - For a user interface, user understands a prototype much better than a text description (get better feedback).

Prototype process

- Objectives for prototype should be made in advance
  - Decide what to put in, what to leave out.
- Must be developed quickly!
- Users test the prototype and evaluate it with respect to the objectives
- Prototypes should be discarded after use:
  - It may be impossible to tune the prototype to meet performance and reliability requirements
  - Prototypes are normally undocumented
  - The structure is usually degraded through quick and dirty design
  - The prototype probably will not meet normal organizational quality standards.

Incremental delivery

- Special case of Incremental Development where each version is delivered to users.
- Generally same advantages as Incremental Development
  - Good response to changing requirements
- Major system functionality is available to users earlier.
- Early increments act as a prototype to help elicit requirements for later increments.
- Highest priority requirements are included in early increments, so they receive the most testing.

Incremental delivery problems

- Generally same problems as Incremental Development
  - Difficult to design and implement common facilities needed by all versions
  - Constant upgrading can degrade structure of code
- Contract negotiations are more difficult
  - The specification is developed in stages
  - Unable to use it as part of the development contract.
- Difficult to get feedback when replacing an existing system:
  - Users won't be motivated to use the less functional new system.

2.4 The (Rational) Unified Process

- Unified Process: A popular software process framework/model
  - a hybrid software process model: iterative and staged.
- Has 4 main phases or stages.
  - correspond to business concerns, not technical activities
- Each phase may contain several iterations.
- Has 6 disciplines (activities) performed across the 4 phases.
- Each phase involves all the disciplines, in varying amounts.

Four phases of UP

- INCEPTION
  - High level requirements established
  - Key risks identified
- ELABORATION
  - Significant elements (core architecture) are programmed and tested
- CONSTRUCTION
  - Remainder of system is built and tested
- TRANSITION
  - The system is fully deployed to the customer

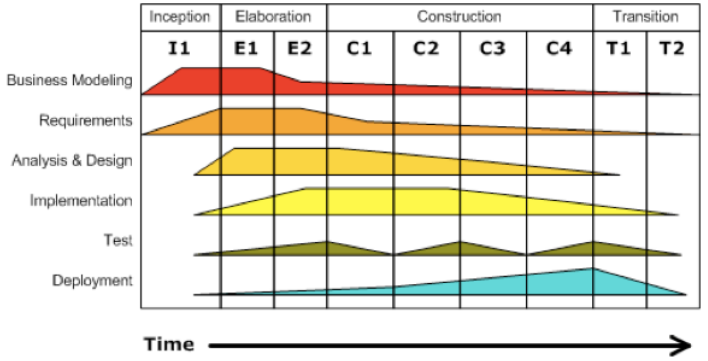
Certain milestones must be completed in each phase, before moving on to the next one.

Disciplines of UP

- Business Modeling
  - business processes are modeled using use cases
- Requirements
- Design
- Implementation
- Testing
- Deployment
  - product is released, distributed, and installed
- Project Management
  - scheduling, managing resources

Phases of UP

- Disciplines over the phases
  - each column is an iteration.



The Rational Unified Process

- Rational Unified Process (RUP) is a refinement or specialization of UP
  - A product from IBM
  - Hyperlinked knowledge base with sample artifacts
  - Enables developer organization to tailor UP to its needs:
    - allows developer to select appropriate elements of the process
    - manages documentation
    - provides tools for applying the process