Lecture 3: Life Cycles and Design Methods

Kenneth M. Anderson
Object-Oriented Analysis and Design
CSCI 6448 - Spring Semester, 2003

Goals for this Lecture

- Review traditional software engineering life cycles
- Introduce the notion of an object-oriented design method
  - Hint: its another name for “life cycle”

Background

- In Software Engineering:

  “Process is King”
  - We want our activities to be coordinated and planned, e.g. “engineered”
  - The reason?
    - A high quality process should increase our ability to create a high quality product

Use of Process

- Car Assembly
  - An assembly line is a process for producing cars.
  - A significant amount of work goes into not just designing a car but into designing the process used to build that car
- Software Engineering
  - The same principles can be applied to developing a software system

Key Difference

- There is a key difference between software engineering and car assembly, however.
- In car assembly, design time for the car is “short”, the majority of the work lies in manufacturing
  - In software engineering, we face the reverse situation, creating new copies of a software system is trivial, it’s the design that is hard
  - Thus, there will be significant differences in the processes used to develop software

Software Life Cycle

- A series of steps that organizes the development of a software product
- Duration can be from days to years
- Consists of
  - people (!)
  - overall process
  - intermediate products
  - stages of the process

Phases of a Software Life Cycle

- Standard Phases
  - Requirements Analysis & Specification
  - Design
  - Implementation and Integration
  - Operation and Maintenance
  - Change in Requirements
  - Testing throughout!
- Phases promote manageability and provide organization

Requirements Analysis and Specification

- Problem Definition ➜ Requirements Specification
  - determine exactly what client wants and identify constraints
  - develop a contract with client
  - Specify the product’s task explicitly
- Difficulties
  - client asks for wrong product
  - client is computer/software illiterate
  - specifications may be ambiguous, inconsistent, incomplete
- Validation
  - extensive reviews to check that requirements satisfy client needs
  - look for ambiguity, consistency, incompleteness
  - check for feasibility, testability
  - develop system/acceptance test plan

Design

- Requirements Specification ➜ Design
  - develop architectural design (system structure)
    - decompose software into modules with module interfaces
  - develop detailed design (module specifications)
    - select algorithms and data structures
  - maintain record of design decisions
- Difficulties
  - miscommunication between module designers
  - design may be inconsistent, incomplete, ambiguous
- Verification
  - extensive design reviews (inspections) to determine that design conforms to requirements
  - check module interactions
  - develop integration test plan

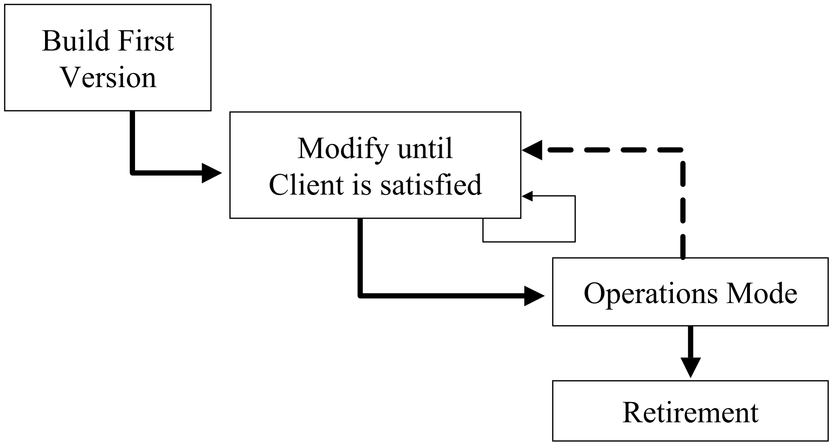
Implementation and Integration

- Design ➜ Implementation
  - implement modules and verify they meet their specifications
  - combine modules according to architectural design
- Difficulties
  - module interaction errors
  - order of integration has a critical influence on product quality
- Verification and Testing
  - code reviews to determine that implementation conforms to requirements and design
  - develop unit/module test plan: focus on individual module functionality
  - develop integration test plan: focus on module interfaces
  - develop system test plan: focus on requirements and determine whether product as a whole functions correctly

Operation and Maintenance

- Operation ➜ Change
  - maintain software after (and during) user operation
  - determine whether product as a whole still functions correctly
- Difficulties
  - design not extensible
  - lack of up-to-date documentation
  - personnel turnover
- Verification and Testing
  - review to determine that change is made correctly and all documentation updated
  - test to determine that change is correctly implemented
  - test to determine that no inadvertent changes were made to compromise system functionality

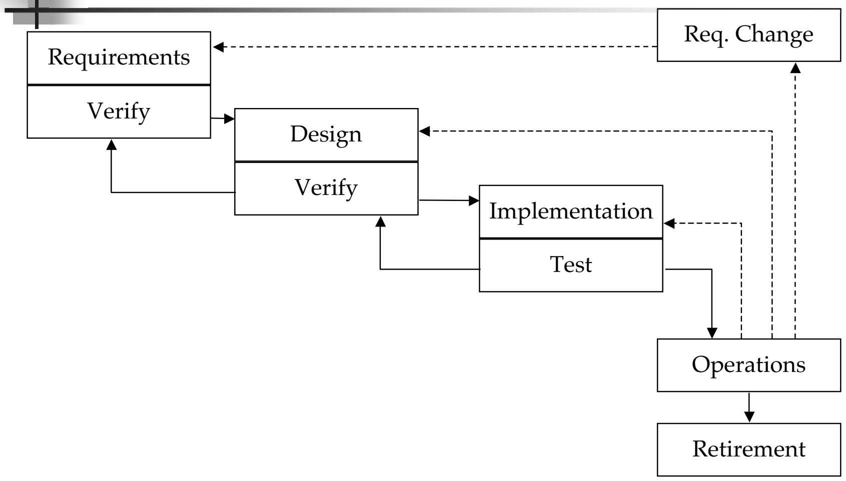
Code-and-Fix (Not a Life Cycle!)



Discussion of Code-and-Fix

- Useful for “hacking”
- Problems become apparent in serious coding efforts
  - No process for things like versioning, configuration management, testing, etc.
  - Difficult to coordinate activities of multiple programmers
  - Non-technical users cannot explain how the program should work
  - Programmers do not know or understand user needs

Waterfall Model



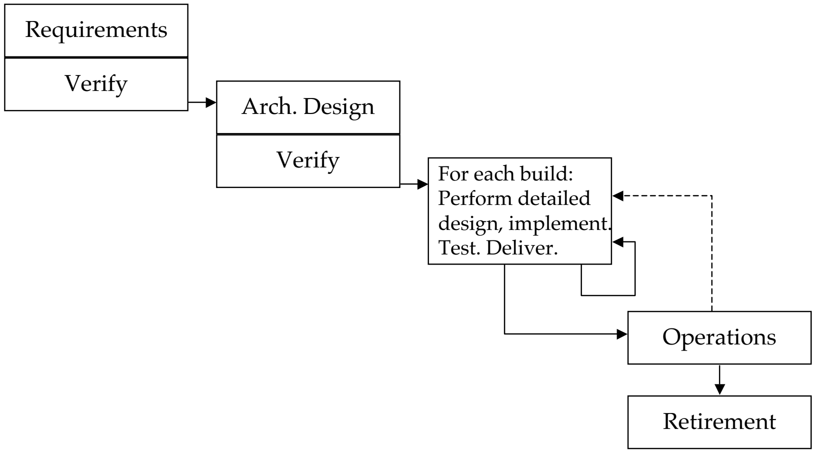
Discussion of Waterfall

- Proposed in early 70s
- Widely used (even today)
- Advantages
  - Measurable Progress
  - Experience applying steps in past projects can be used in estimating duration of steps in future projects
  - May produce software artifacts that can be reused in other projects

Waterfall, continued

- The original waterfall model had disadvantages because it disallowed iteration
  - Inflexibility
  - Monolithic
  - Estimation is difficult
  - Requirements change over time
  - Maintenance not handled well
- These are problems with other life cycle models as well
- The “waterfall with feedback” model was created in response
  - Our slides show this model

Incremental


Requirements
Verify
Arch. Design
Verify
For each build: Perform detailed design, implement. Test. Deliver.
Operations
Retirement

Discussion of Incremental Model

- Used by Microsoft
  - Programs are built everyday by the build manager
  - If a programmer checks in code that “breaks the build” they become the new build manager!
  - Iterations are classified according to features
    - e.g. features 1 and 2 are being worked on in this iteration, features 3 and 4 are next

Summary

- Life cycles make software development
  - predictable
  - repeatable
  - measurable
  - efficient
- High-quality processes should lead to high-quality products
  - at least it improves the odds of producing good software

Survey of OOA&D Methods

- Generalization
  - Taken from “SE: A Practitioner’s approach, 4th ed.” by Roger S. Pressman, McGraw-Hill, 1997
- The Booch Method
- The Jacobson Method
- The Rambaugh Method
- The Unified Software Process

OO Methods In general...

- Obtain customer requirements for the OO System
  - Identify scenarios or use cases
  - Build a requirements model
- Select classes and objects using basic requirements
- Identify attributes and operations for each object
- Define structures and hierarchies that organize classes
- Build an object-relationship model
- Build an object-behavior model
- Review the OO analysis model against use cases
  - Once complete, move to design and implementation: These phases simply elaborate the previously created models with more and more detail, until it is possible to write code straight from the models

Detailed comparisons

- What follows is a barebones description of each method, detailed comparisons can be found in:
  - Graham, I. Object-Oriented Methods, Addison-Wesley, Third Edition, 2001
  - For related links:
  - <http://www.ultranet.com/~lebrun/Steven/Computer/Programming/Object-Oriented.html>

Background on OO Methods

- An OO Method should cover and include
  - requirements and business process modeling
  - a lightweight, customizable process framework
  - project management
  - component architecture
  - system specification
    - use cases, UML, architecture, etc.
  - component design and decomposition
  - testing throughout the life cycle
  - QA and configuration management
  - Process Patterns

Process Patterns

- A pattern in the form of
  - Whenever your goal is A
and your current situation is B
then try doing C
    - (but be aware of prerequisite P, risk R, side-effect S, time-scale T, etc.)

The Booch Method

- Identify classes and objects
  - Propose candidate objects
  - Conduct behavior analysis
  - Identify relevant scenarios
  - Define attributes and operations for each class
- Identify the semantics of classes and objects
  - Select scenarios and analyze
  - Assign responsibility to achieve desired behavior
  - Partition responsibilities to balance behavior
  - Select an object and enumerate its roles and responsibilities
  - Define operations to satisfy the responsibilities

Booch, continued

- Identify relationships among classes and objects
  - Define dependencies that exist between objects
  - Describe the role of each participating object
  - Validate by walking through scenarios
- Conduct a series of refinements
  - Produce appropriate diagrams for the work conducted above
  - Define class hierarchies as appropriate
  - Perform clustering based on class commonality
- Implement classes and objects
  - In analysis and design, this means specify everything!

The Jacobson Method

- Object-Oriented Software Engineering
  - Primarily distinguished by the use-case
  - Simplified model of Objectory
    - Objectory evolved into the Rational Unified Software Development Process
  - For more information on this Objectory precursor, see
    - Jacobson, I., Object-Oriented Software Engineering, Addison-Wesley, 1992.

Jacobson, continued

- Identify the users of the system and their overall responsibilities
- Build a requirements model
  - Define the actors and their responsibilities
  - Identify use cases for each actor
  - Prepare initial view of system objects and relationships
  - Review model using use cases as scenarios to determine validity
- Continued on next slide

Jacobson, continued

- Build analysis model
  - Identify interface objects using actor-interaction information
  - Create structural views of interface objects
  - Represent object behavior
  - Isolate subsystems and models for each
  - Review the model using use cases as scenarios to determine validity

The Rambaugh Method

- Object Modeling Technique (OMT)
  - Rambaugh, J. et al., Object-Oriented Modeling and Design, Prentice-Hall, 1991
- Analysis activity creates three models
  - Object model
    - Objects, classes, hierarchies, and relationships
  - Dynamic model
    - object and system behavior
  - Functional model
    - High-level Data-Flow Diagram

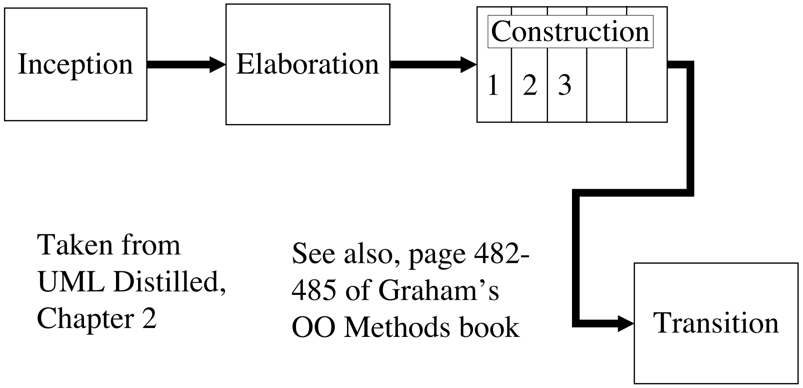
Rambaugh, continued

- Develop a statement of scope for the problem
- Build an object model
  - Identify classes that are relevant for the problem
  - Define attributes and associations
  - Define object links
  - Organize object classes using inheritance
- Develop a dynamic model
  - Prepare scenarios
  - Define events and develop an event trace for each scenario
  - Construct an event flow diagram and a state diagram
  - Review behavior for consistency and completeness

Rambaugh, continued

- Construct a functional model for the system
  - Identify inputs and outputs
  - Use data flow diagrams to represent flow transformations
  - Develop a processing specification for each process in the DFD
  - Specify constraints and optimization criteria
- Iterate!

Rational Unified Process: Overview



Taken from UML Distilled, Chapter 2

See also, page 482-485 of Graham's OO Methods book

Inception

- High-level planning for the project
- Determine the project's scope
- If necessary
  - Determine business case for the project
    - Estimate cost and projected revenue

Elaboration

- Develop requirements and initial design
- Develop Plan for Construction phase
- Risk-driven approach
  - Requirements Risks
  - Technological Risks
  - Skills Risks
  - Political Risks

Requirements Risks

- Is the project technically feasible?
- Is the budget sufficient?
- Is the timeline sufficient?
- Has the user really specified the desired system?
- Do the developers understand the domain well enough?

Dealing with Requirements Risks

- Construct models to record Domain and/or Design knowledge
  - Domain model (vocabulary)
  - Use Cases
  - Design model
    - Class diagrams
    - Activity diagrams
- Prototype construction

Dealing with Requirements Risks

- Begin by learning about the domain
  - Record and define jargon
  - Talk with domain experts
    - Oftentimes end-users!
- Next construct Use cases
  - What are the required external functions of the system?
  - Iterative process; Use Cases can be added as they are discovered

Dealing with Requirements Risks

- Finally, construct Design model
  - Class diagrams identify key domain concepts and their high-level relationships
  - Activity diagrams highlight the domain's work practices
    - A major task here is identifying parallelism that can be exploited later
- Be sure to consolidate iterations into a final consistent model

Dealing with Requirements Risks

- Build prototypes
  - Used only to help understand requirements
  - Throw them all out!
    - Do not be tied to an implementation too early
    - Make use of rapid prototyping tools
      - 4th Generation Programming Languages
      - Scripting and/or Interpreted environments
      - UI Builders
- Be prepared to educate the client as to the purpose of the prototype

Technology Risks

- Are you tied to a particular technology?
- Do you "own" that technology?
- Do you understand how different technologies interact?
- Techniques
  - Prototypes!
  - Class diagrams, package diagrams
  - "Scouting" — evaluate technology early

Skill Risks

- Do the members of the project team have the necessary skills and background to tackle the project?
- If not
  - Training, Consulting, Mentoring and Hiring new people are available options!

Political Risks

- How well does the proposed project mesh with corporate culture?
  - Consider the attempt to use Lotus Notes at Arthur Anderson
    - Lotus Notes attempts to promote collaboration
    - Arthur Anderson consultants compete with each other!
  - Consider e-mail: any employee can ignore the org chart and mail the CEO!

Political Risks, continued

- Will the project directly compete with another business unit?
- Will it be at odds with some higher level manager's business plan?

- Any of these can kill a project…
- Examples from students?

Reference

- Lotus Notes vs. Arthur Anderson
  - Orlikowski, W. J. (1992). "Learning from Notes: Organizational Issues in Groupware Implementation". Proceedings of ACM CSCW'92 Conference on Computer-Supported Cooperative Work: 362-369.
- If you are interested you can borrow my copy of the CSCW'92 proceedings to make a copy

Ending Elaboration

- Baseline architecture constructed
  - List of Use cases (with estimates)
  - Domain Model
  - Technology Platform
- AND
  - Risks identified
  - Plan constructed
    - Use cases assigned to iterations

Construction

- Each iteration produces a software product that implements the assigned Use cases
  - Additional analysis and design may be necessary as the implementation details get addressed for the first time
- Extensive testing should be performed and the product should be released to (some subset of) the client for early feedback

Transition

- Final phase before release 1.0
- Optimizations can now be performed
  - Optimizing too early may result in the wrong part of the system being optimized
  - Largest boosts in performance come from replacing non-scalable algorithms or mitigating bottlenecks