

Software Engineering Notes

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Part I

Notes

Chapter 1

January 15, 2012

1.1 Overview

Software Engineering - The application of sound engineering practices to software creation and maintenance.

1.1.1 Software development Life Cycle (Traditional Approach)

- Requirements Phase
- Analysis or Specification Phase
- Design Phase
- Implementation/Integration Phase
- Maintenance Phase
- Retirement

Requirements Phase

- Determining the NEEDS and WANTS of the client or customer.
- Determining the constraints of the system.

Analysis or Specification Phase

- After analyzing the requirements, construct a *specification document* which explicitly describes what the product is to do, and the constraints under which it must operate.
- This includes the description of the input, output, actions, and UI.

- The specification document can be used as part of a contract with the client.

Problems with the Spec Document

1. Ambiguity - one sentence may have more than one interpretation.
2. Incompleteness - relevant fact or requirement is left out.
3. Contradiction - two places in the spec document are in conflict.

Design Phase

- Construct an *Architectural Design*.
 - Construct a *Detailed Design*.
 - Test for *traceability*.
1. Architectural Design - Description of the product in terms of modules.
 2. Detailed Design - Description of each module.
 3. Traceability - each part of the design can be traced to a statement in the specification document.

Implementation Phase

- Code each module from the detailed design.
- Programmer tests his/her own code separately.
- Modules are combined and tested by developers.
- Product is tested by SQA group. This is called product testing.
- Project is given to the client for acceptance testing.

Maintenance Phase

- Corrective Maintenance - bug squashing
- Enhancement Maintenance - Updates
 - Perfective - client makes new demands
 - Adaptive - changes in the environment of the product requires changes in the software.
- Perform regression testing - insuring that changes have not affected already working functionality.

Retirement Phase

- Determining if desired changes are too costly.
- Determining if a product is obsolete.

1.1.2 Four Components of the Software Engineering Enterprise

The four P's

1. Process
2. Project
3. People
4. Product

Process

- The process is sometimes called the life-cycle model or development sequence.
 - Waterfall
 - Spiral
 - Incremental Build
- Makes use of several process frameworks.
 - Personal Software Process (PSP)
 - Team Software Process (TSP)
 - Capability Maturity Model (CMM)
- Documentation Standards
 - IEEE
 - ANSI

Project

- The set of activities needed to produce the required product.
- Project management is extremely important.
- Many projects are not about developing new products, but maintaining already existing *legacy* systems.

People

- Team Organization
- Team Management
- Relationship with customer or client
- Relationship with end users
- Communication with upper management

Product

Includes

- Requirement Specification Document
- Design Document
- Source Code
- Executable
- User Manuals

Chapter 2

January 17, 2013

2.1 Traditional Software Engineering Process

2.1.1 Historical Influences

- Structured programming (Edsger Dijkstra's letter calling "GOTOs" harmful) uses sequence control, iteration, invoking functions
- Object Oriented paradigm: the use of objects with data and functionality which can represent real-world entities.

Note:

Silver Bullet ca. 1980s

Likened the software crisis to a werewolf. Object Oriented Paradigm was the Silver Bullet.

It did not work as expected.

- Design Patterns: stock of reusable design elements (templates)

2.1.2 Component Reuse

A component as defined by Meyer is "a program element satisfying:"

1. The element may be used by other program elements. (Clients)
2. The clients and their authors do not need to be known to the element's author

2.1.3 Key Expectations of Software Engineering

1. Decide in advance what the specific quality measures are to be for the project and product.
Predetermine quantitative quality goals.

2. Gather data on all projects to form a basis for estimating future projects.
3. All requirements, designs, code and test materials should be freely and easily available to all members of the team.
Source code should always be available to all team members in an easily accessible and interpreted way.
Git, Mercurial, etc.
4. A process should be followed by all team members. *Uniformity*
 - (a) Design only against requirements.
 - (b) Program only against design.
 - (c) Test only against requirements and design.
ALWAYS FOLLOW THE RECIPE!
5. Measure and achieve quality goals.

2.2 Methods

Be able to draw and discuss these.

2.2.1 Waterfall Method

SEE DIAGRAM 52.9 ON PG 53.

- First described by William(?) Royce in 1970.
- No phase is complete until documentation for that phase has been completed and approved by the SQA group.
Very orderly; heavy on documentation.
- Has been used with great success on a variety of products.
- Feedback loops permits modifications to be made to the previous phase.

Advantages

1. Enforced disciplined approach
2. Requirement that documentation be provided at each phase.
3. All products of the phase must be checked by SQA.
4. Inherent aspect of each phase is testing.

Disadvantages

- The resulting specification document may not be able to be understood by the client.
- It can lead to the construction of product that does not meet the client's needs.

2.2.2 Rapid Prototype Model

SEE DIAGRAM ON PG 55. Construction of a functional subset of the desired product in order to allow the client and the developer to interact.

Keyword is rapid. This is a thrown-together, proof-of-concept type project; a mock-up.

Advantages

- The process is linear and possibly faster than the Waterfall Model
- Increases interaction between client and developer.

Disadvantages

- Client may inaccurately think the product is almost complete when viewing the prototype.
- Developer may attempt to use the prototype as part of the final product.

2.2.3 Waterfall-Rapid Prototype Hybrid

May form a hybrid model using the rapid prototype as the first phase in the Waterfall Model in order to increase interaction but allow for feedback loops within the development of the product.

2.2.4 Incremental Model

Software is implemented, integrated, and tested as a series of incremental builds.
Code pieces providing specific functions.

Advantages

1. Results in builds which can be developed in weeks, not months or years.
2. End user need not learn the entire product at one time.
3. Client need not pay for the entire product at one time.
4. Developer gets paid earlier.
(At each build delivery)

5. Open-ended design makes maintenance easier.
6. Easier to make changes during development.

Disadvantages

1. Each new build must fit in without destroying existing builds.
Regression Testing
2. Requires more careful to design to make it open to additions.
3. Can degenerate to a build and fix product if broken into too few builds.

2.2.5 Spiral Model

SEE FIGURE 2.12 ON PG 63 AND FIGURE 2.13 ON PG 65.

- A Waterfall Model with each phase preceded by risk analysis in an attempt to control or resolve risk.
- Each phase is 360.
- The measure of the radius is the cumulative cost to date.
- The measure of the angle is the progress measure.
Each phase is 360.
Requires a very experienced engineer.

Advantages

1. The emphasis on alternatives and constraints supports the reuse of existing software.
2. The incorporation of software quality as a specific objective.
3. Answers the question of how much testing should be performed in terms of risks.
4. Maintenance is simply another cycle of the spiral, the same as development.

Disadvantages

1. Intended exclusively for internal development.
Client and developer are members of the same organization.
2. *Applicable only to large-scale projects.*
3. Must have developers who are skilled at pinpointing the possible risks.

2.3 Agile Methods

2.3.1 General

According to the Agile Manifesto, they value:

- Individuals and interactions over processes and tools.
- Working software over comprehensive documentation.
- Customer collaboration over contract negotiation.
- Responsiveness to change over following a plan.
YOU DON'T ALWAYS HAVE TO FOLLOW THE RECIPE!

Traits

- Highly iterative
- Pair programming with a focus on teamwork and ego-less programming.
THIS IS MANDATORY.
- Early and planned testing.
- Story cards *Similar to storyboards in movies.*
- Refactoring *Turning working code into better code.*
- Feedback

Principles Behind the Agile Manifesto

1. Our highest priority is to satisfy the customer through early and continuous delivery of valuable software.
2. Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive disadvantage.
3. Deliver working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale.
4. Business people and developers must work together daily throughout the project.
5. Build projects around motivated individuals. Give them the environment and support they need and trust them to get the job done.
6. The most efficient and effective method of conveying information to and within a development team is face-to-face conversation.
7. Working software is the primary measure of progress.

8. Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely.
9. Continuous attention to technical excellence and good design enhances agility.
10. Simplicity - the art of maximizing the amount of work not done - is essential.
11. The best architectures, requirements, and designs emerge from self-organizing teams.
12. At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior accordingly.

Chapter 3

January 22, 2013

3.1 Refactoring

- Reduce software complexity
- Improve internal structure while preserving the behavior of the code.
Prettifying
- Improve software quality
Readability, execution efficiency, size efficiency, etc.
- Performed in response to "bad smells" in the code, undesirable characteristics
Martin Fowler
- Automated or manual

3.2 Teams

Team - a group of professionals organized in order to complete the task of creating a large software project.

3.2.1 Team Structure

Project Factors Related to Structure of the Team

1. Difficulty of the problem
2. Size of the program in LOC or Function Points
LOC stands for Lines of Code
3. Time the team will stay together

4. Degree of modularity for program
5. Required quality and reliability
6. Rigidity of delivery date
7. Degree of communication required

Jelled Team

- A group of people which are so tightly knit that the attitude is that the whole is greater than the sum of the parts
- Egos are forgotten and the team becomes important
- Exhibits cohesiveness, team spirit, common definition of success
- Generally more productive, more motivated, and happier

Why Don't All Teams Jell?

- A frenzied work atmosphere
- High frustration causing friction among team members
- A "fragmented or poorly coordinated" software process
- An unclear definition on the team
- "Continuous and repeated exposure to failure" - M. Jackman *Homeopathic Remedies for Team Toxicity*

Necessary Team Traits

Personality

- Openness - intellectual curiosity
- Conscientiousness - self-discipline, pushing toward goals
- Extroversion - energy, emotions, seek company of others
Being a people person
- Agreeableness - compassionate and cooperative
- Neuroticism - how a person responds to stress, emotional stability

How to Make Personality Traits Work

1. Recognize people have different types of personalities
2. Assemble a diverse team covering a range of personalities
3. Create an open, honest, tolerant atmosphere in team meetings

3.2.2 Roles

- Team Leader - Responsible for overseeing all aspects of the team project; holds the tie-breaking vote.
- Technical Lead - Expert on all technical aspects of the project, in particular the hardware and software used for development.
- Designer - Designs the project and breaks the project into smaller pieces (*Modules*) for the programmers.
- Lead Programmer - Needs to have an understanding of the project as a whole; organizes all of the other programmers.
- Technical Writer - Writes all documentation for the project (*Team meeting minutes, Specification Document, Users' Manual*)
- Configuration Management - Maintains the code base for the project; could include CVS responsibilities.
- Quality Assurance - Writes, maintains, and conducts all testing associated with the project.

3.2.3 Organizational Structures

- Democratic Team
- Hierarchical or Chief Programmer
- Team Manager/Team Leader
- Synchronize-and-Stabilize Team
- Agile Team

Democratic Team

- Group of up to 10 programmers
- Equal partnership with egoless programming
- Works well if the group is small, highly competent
- Problem with who is in charge
- Positive attitude about finding fault
- Good in research environment with difficult problem

Hierarchical or Chief Programmer

- One overall manager (*Chief Programmer*)
- Everyone understands the lines of authority
One boss.
- Team members tend to participate less in decisions; decisions are handed down from above
- May have a Programming Secretary and a Backup Programmer for the Chief Programmer
- Difficult to find one person adept at both managing and programming.

Team Manager/Team Leader

See Figure 4.4, pg. 114

- Split the responsibilities of Chief Programmer into Team Manager and Team Leader
- The Team Manager handles the nontechnical management
- The Team Leader deals with the technical issues of the project
- Results in programmers having two bosses
- May be difficult to determine if an issue is technical or nontechnical

Technical Organizational Structure for Large Projects

- One Project Leader oversees several team leaders
- Each team leader has several programmers for which he/she is responsible
- Clear lines of communication
Two level structure

Synchronize-and-Stabilize Team

Has been used by Microsoft

- Small team led by a manager and having three to eight developers and three to eight testers working one-to-one with the developers
- Developers are given freedom to design and implement their portions as they wish
- Each day, the partial components are tested and debugged.
- Encourages creativity and innovation yet the daily synchronization keeps the project on track.

Agile Team

- Work in pairs (MANDATORY)
- Provide instant review
- Create test cases which are used for daily testing
- Remove the problem if one developer leaves, the knowledge does not disappear about a portion of the project

Chapter 4

January 24, 2013

4.1 Tools for Software Engineers

- Analytic (Theoretical) Tools:
 1. Stepwise Refinement
 2. Cost-Benefit Analysis
 3. Divide-and-Conquer
 4. Separation of Concerns
 5. Software Metrics
- Software Tools (CASE: Computer-Aided Software Engineering)

4.1.1 Analytic Tools

Stepwise Refinement

- Process whereby a project is successively decomposed into more detailed instructions.
- In each step, a given task is written as a set of subtasks.
- Term was first coined by Niklaus Wirth in 1971.
- Helps to concentrate on relevant aspects of the current development phase and ignore details that need not be considered.
- A postponement of decisions on details until as late as possible.
- Critical to object-oriented paradigm.

Cost-Benefit Analysis

- Comparing estimated future benefits against future costs for a certain decision.
- Problems occur in that intangible benefits may be hard to quantify.
- May use past experience to project the estimates for benefits or costs.

Divide-and-Conquer

- Most agree this is the oldest analytical tool used in Software Engineering.
- Break a large problem into smaller subprograms that should be easier to solve.
- Idea used in the Unified Process.
- Good concept but no details in the how... GET THIS BULLET
- *Key difference from Stepwise Refinement is that Divide-and-Conquer does not necessarily procrastinate details.*

Separation of Concerns

- First introduced by Dijkstra in 1974.
- Process of breaking a software project into components which overlap as little as possible in relationship to functionality.
- Regression faults are minimized.
If every component does one function (High Cohesion), making changes won't affect a lot of things.
- Components are more reusable.

Software Metrics

Measurements used to indicate:

- Size (LOC - Lines of Code)
- Duration (Months, years)
- Effort (Person-Months)
- Quality (Fault Density - Faults/1000LOC)
- Efficiency (Faults/Unit of time)
- Reliability (Mean time between failures)

Product/Process

4.1.2 CASE Tools

- UpperCASE or front-end tools - used in the requirements, analysis and design workflows
- LowerCASE or back-end tools - used in the implementation and maintenance activities

Types of CASE Tools

- Data Dictionary - computerized list of all data defined within the product (type and location defined)
Could be Upper or LowerCASE
- Consistency Checker - tool which checks that everything in the design is in the specification document and everything in the specification document is in the design.
- Report Generator - tool which generates code needed for producing a report.
- Screen Generator - tool which generates the code necessary for a data capture screen.
- Structured Editor - a text editor which is designed to understand the structure of a program in a programming language, aiding in syntax fault prevention or early detection.
- Pretty Printer or Formatter - code often included with the structured editor which makes use of the language syntax structure to display the code in a standard manner (indenting, highlighting reserved words or comments)
Try Sublime Text 2!
- On-line Interface Checker - editor know every subprogram declared within the product and their parameter lists.
- Operating System Front End - tool which allows the programmer to give commands to the operating system from within the editor.
- Source Level Debugger *LowerCASE*
- Interactive Source Level Debugger *LowerCASE*
- Version Control Tool - keeps detailed record of each version of the project.
Check out Git with GitHub or BitBucket!
- Configuration Control Tool - manages multiple variations. *LowerCASE*

Grouped CASE Tools

- CASE Workbench - collection of CASE tools that together support one or two activities.
- CASE Environment - collection of CASE tools which support the entire software process.

4.2 Software Versions

- During maintenance, at least two versions of the product will exist: the old version and the new version.
- Revision - what we call the new version.
- Configuration - the specific version of each artifact from which a given version of the complete product is built.

Chapter 5

January 29, 2013

5.1 Phases of Unified Process

5.1.1 Inception Phase

- Determine whether it's worthwhile to develop the target product
- Determine economic viability
- Steps
 1. Obtain domain knowledge
 2. Build business model
 - Understand how the client operates within the domain.*

Questions to consider:

1. Is the proposed software cost effective?
2. Can the proposed software be delivered on time?
3. What risks are involved in developing the software and how can these risks be mitigated?

Identify Risks

1. Technical risks
 - Necessary experience?
 - New hardware needed and will it be delivered on time?
 - Software tools needed?
2. Not getting the requirements right
3. Not getting the architecture (design) right

Documentation in the Inception Phase

- Initial version of the domain model
- Initial version of the business model *How the client operates in their domain.*
- Initial version of the requirements artifacts
- Preliminary version of the analysis artifacts
- Preliminary version of the architecture
- Initial list of risks
- Initial use cases
- Plan for elaboration phase
- Initial version of the business case
Document that describes the cost-effectiveness of taking on the project

5.1.2 Elaboration Phase

- The aim is to refine the requirements, refine the architecture, monitor the risks, refine the business case, and produce the software project management plan.
- Major activities are refinements of the previous phase.

Elaboration Phase Deliverables

- Completed domain model
- Completed business model
- Completed requirements artifact
- Completed analysis artifacts
- Updated version of the architecture
- Updated list of risks
- Software Project Management Plan (SPMP)
- Completed business case

5.1.3 Construction Phase

- Aim is to produce the first operational-quality version of the product (beta release)
- Emphasis is on implementation and testing
- Components are coded and unit tested
- Components are combined (integrated) and tested again.

Construction Phase Deliverables

- Initial user manual and other manuals as needed
- All the artifacts of the beta release version
- Completed architecture
- Updated risk list
- Software Project Management Plan (SPMP)
- Updated business case if needed

5.1.4 Transition Phase

- Aim is to ensure that the client's requirements have been met
- Driven by feedback from the locations where the beta version is installed and tested
- Manuals are completed
- Faults are corrected
- Discover any unidentified risks

Transition Phase Deliverables

- All the artifacts of the final version
- Completed manuals

Refer to pg. 88 of the book.

5.2 Testing

Testing - continual process carried on during the entire life cycle of software.

V and V

- Verification - determining whether a phase has been correctly carried out (at the end of the phase)
- Validation - testing just before a product is delivered to the client to determine if it satisfies the specifications

Use of the Term Testing We use the term testing instead of V and V because they imply that testing can wait until certain points in the process like the end of a phase, when testing must occur throughout the process.

5.2.1 Fault, Failure, Error, Defect

- Fault - human mistake created in software
- Failure - observed incorrect behavior due to a fault
- Error - amount by which a result is incorrect
- Defect - generic term used to encompass fault, failure, and error

5.3 Software Quality

- Extent to which the product satisfies its specifications
- Adherence to specifications
- Must be ensured at all times, not just added at the end of the product
- Every software developer must be personally responsible for the quality of their work.

5.3.1 Software Quality Assurance

SQA group oversees the quality throughout the process

- Adherence to standards
- Correctness of each workflow
- Independent of the development team

5.3.2 Categories of Testing

1. Non-Execution-Based Testing (Reviews)

- Walkthroughs
 - 4-6 person team (Experience Senior Staff)
 - * Manager of the current workflow
 - * Member of the team on the current workflow
 - * Member of the team on the subsequent workflow
 - * Client Representative
 - * SQA group member
 - Material distributed to allow participants to prepare
 - Each reviewer develops two lists: things they don't understand, things they think are incorrect
 - Purpose is to find faults in a workflow or document such as the specification or the design document and create a list of faults for later correction

Ways to conduct a walkthrough

- (a) Participant Driven - members present their lists to the team creating the document being tested which respond to each item (clarify questions, repair faults)
 - (b) Document Driven - chair walks the members through the document with stops at the unclear or possible faults
- Inspections
 - Proposed by Fagan in 1976 for testing designs and
 - Consists of five formal steps
 - Conducted by team of size 4-5
 - * Moderator - both manager and leader of the inspection team
 - * Reader - leads team through the document
 - * Recorder - produces written report of detected faults
 - * Implementer/Tester
 - Steps:
 - (a) Overview - presentation by one individual responsible for producing it after which given to participants
 - (b) Preparation - participants try to understand the document using lists of fault types and create checklist
 - (c) Inspection - one participant walks through using the checklists with the moderator creating a written report
 - (d) Rework - using the written report of faults, the individuals which created the document resolve the faults
 - (e) Follow-Up - moderator makes sure that everything in the report has been corrected or addressed and that no new faults were created in repairing the original faults

Comparison of Walkthroughs and Inspections

- Walkthroughs are 2 steps and inspections are more formal 5 steps
- Inspections generally take longer but the extra time and effort spent can be cost effective

2. Execution-Based Testing

Chapter 6

January 31, 2013

6.1 Testing

6.1.1 Strengths of Using Reviews

1. Effective way to find faults in the specification document or the design document.
2. Faults detected earlier in the process are less costly to repair or remove.

6.1.2 Metrics for Inspections

1. Inspection Rate - the number of pages inspected per hour (for specifications and designs) or lines of code inspected per hour (for code inspection)
2. Fault Density - number of faults per page or number of faults per KLOC
3. Fault Detection Rate - number of major and minor faults detected per hour
4. Fault Detection Efficiency - number of major and minor faults detected per person-hour

These methods are used to determine whether the inspection process is working.

Goals and Limits of testing

- Goal: To maximize the number and severity of defects found per dollar spent
- Limit: Testing can only determine the presence of defects, never their absence. Correctness proofs are the only manner of proving the absence of defects.

6.1.3 Levels of Testing

1. Unit Testing - The earliest type of testing, testing the parts of the application (functions, modules, module combinations)
2. Integration Testing - Validates the overall functionality of each stage
3. Acceptance Testing - Validates the final product

6.1.4 Steps for Unit Testing

1. Plan the general approach, resources, and schedule.
2. Determine requirements-based characteristics to be tested.
3. Refine the general plan.
4. Design the set of tests.
5. Implement the refined plan and design.
6. Execute the test procedures.
7. Check for termination.

6.1.5 Test Types

- Black Box - Check correct output for given input as specified by the requirements
- White Box (or Clear Box) - Design test of cover all paths through the application.
- Gray Box - Consider limited details of the application with some of the Black Box techniques.

Black Box Testing

- Equivalence Partitioning - Division of the test input data into subsets
- Boundary Value Analysis - Testing for values which separate acceptable and unacceptable ranges.

White Box Testing

- Statement Coverage - Every statement should be executed by at least one test.
- Decision Coverage - Every branch of decision statements is executed.

6.1.6 Planning Unit Tests

1. Decide what the units are to be and who will test them.
2. Decide how unit tests will be documented.
3. Determine the extent of unit testing.
4. Decide how and where to get the test input.
5. Estimate the resources required.
6. Arrange to track time, number, type, and source of defects.

6.1.7 Unit Testing of Methods

1. Verify operation at normal parameter values.
2. Verify operation at limit parameter values.
3. Verify operation outside parameter values.
4. Ensure that all instructions execute.
5. Check all paths - both sides of branches.
6. Check the use of all called objects.
7. Verify the handling of all data structures.
8. Verify the handling of all files.
9. Check normal termination of all loops.
10. Check abnormal termination of all loops.
11. Check normal termination of all recursion.
12. Check abnormal termination of all recursion.
13. Verify the handling of all error conditions.
14. Check timing and synchronization.
15. Verify all hardware dependencies.

6.1.8 Class Testing

1. Method Combination test
2. Attribute-Oriented Test
3. Testing Class Invariants
4. State-based Tests

6.1.9 What is Tested During Execution Based Testing?

- Utility - How useful it is or how it meets the needs of the user
- Reliability - Measuring the mean time between failures; reliable software rarely fails
- Robustness - valid output for valid input, error conditions handled correctly (satisfying the specifications)
- Performance - How well it meets the constraints