Midterm Review

CIS 422/522

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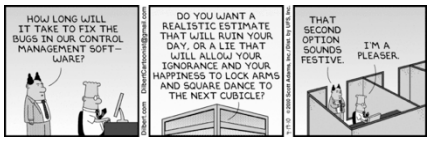


The "Software Crisis"

- Have been in "crisis" since the advent of big software (roughly 1965)
- What we want for software development
  - Low risk, predictability
  - Lower costs and proportionate costs
  - Faster turnaround
- What we have:
  - High risk, high failure rate
  - Poor delivered quality
  - Unpredictable schedule, cost, effort
  - Examples: Ariane 5, Therac 25, Mars Lander, DFW Airport, FAA ATC, Cover Oregon
- Characterized by **lack of *control***

Large System Context

- Discuss issues in terms of large, complex systems
  - Multi-person: many developers, many stakeholders
  - Multi-version: intentional and unintentional evolution
- Quantitatively distinct from small developments
  - Complexity of software rises exponentially with size
  - Complexity of communication rises exponentially
- Qualitatively distinct from small developments
  - Multi-person introduces need for organizational functions, policies, oversight, etc.
  - More stakeholders and more kinds of stakeholders
- We can only approximate this in our projects

Implications: the Large System Difference

- Small system development is driven by technical issues (I.e., programming)
- Large system development is dominated by organizational issues
  - Managing complexity, communication, coordination, etc.
  - Projects fail when these issues are inadequately addressed
- Lesson #1: **programming ≠ software engineering**
  - Techniques that work for small systems often fail utterly when scaled up
  - Programming alone won't get you through real developments or even this course

View of SE in this Course

- The purpose of Software Engineering is to *gain* and *maintain* intellectual and managerial control over the products and processes of software development.
  - **Intellectual control**: able to make rational development decisions based on an understanding of the downstream effects of those choices.
  - **Managerial control** means we likewise control development *resources* (budget, schedule, personnel).

Course Approach

- Learn methods for acquiring and maintaining control of software projects (two threads)
- Managerial control
  - Team organization and people management
  - Organizing people and tasks
  - Planning and guiding development
- Intellectual control
  - Establishing and communicating exactly what should be built
  - Making effective decisions about system properties (behavioral and developmental)
  - Choosing appropriate order for decisions and ensuring feedback/correction

The Software Lifecycle

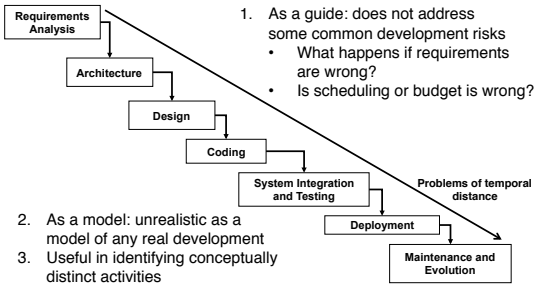
Need to Organize the Work

- Nature of a software project
  - Software development produces a set of interlocking, interdependent work products
    - E.g. Requirements -> Design -> Code
  - Implies dependencies between tasks
  - Implies dependencies between people
- Must organize the work such that:
  - Every task gets done
  - Tasks get done in the right order
  - Tasks are done by the right people
  - The product has the desired qualities
  - The end product is produced on time

Usefulness of Life Cycle Models

- Application of “divide-and-conquer” to software processes and products
  - Identify distinct process objectives
  - Can then address each somewhat separately
- Intended use
  - Provide guidance to developers in what to produce and when to produce it
  - Provide a basis for planning and assessing development progress
- Never an accurate representation of what really goes on

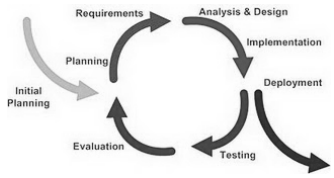
A "Waterfall" Model



1. As a guide: does not address some common development risks
   - What happens if requirements are wrong?
   - Is scheduling or budget is wrong?
2. As a model: unrealistic as a model of any real development
3. Useful in identifying conceptually distinct activities

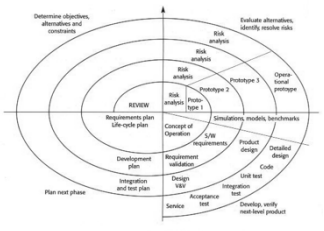
Characteristic Processes: The Iterative Model

- Process is viewed as a sequence of iterations
  - Essentially, a *series of waterfalls*
- Addresses some common waterfall risks
  - Risk that software cannot be completed – build incremental subsets
  - Risk of building the wrong system – stakeholder have opportunities to see the software each increment
  - Also, can double check feasibility, schedule, budget and others issues

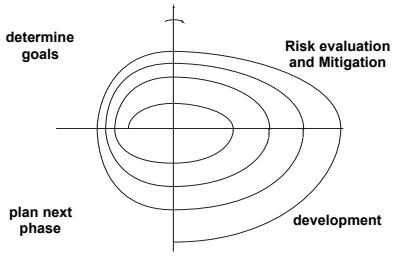


Characteristic Processes: The Spiral Model

- Process viewed as repeating cycles of increasing scale
- Identify risks and determine (next set of) requirements
- Each cycle builds next version by extension, increasing scale each time
- Explicit Go/No-Go decision points in process

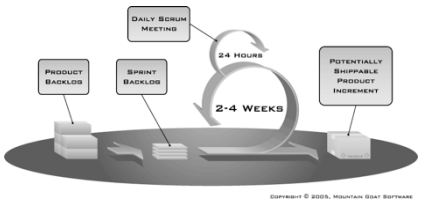


Spiral Model



Characteristic Processes: Agile (e.g. scrum)

- Process viewed as nested sequence of builds (sprints)
  - Each build adds very small feature set (one or two)
  - Nightly build/test, frequent customer validation
  - Focus on delivering code, little or no time spent on documentation



Process Objectives

- Objective: proceed in a controlled manner from stakeholder needs to a design that demonstrably meets those needs, within design and resource constraints
  - Understand that any process description is an abstraction
  - Always must compensate for deviation from the ideal
  - Still important to have a well-defined process to follow and measure against
- Choose process to provide an appropriate level of control for the given product and context
  - Sufficient control to achieve results, address risks
  - No more than necessary to contain cost and effort
- Question of control vs. cost: processes introduce overhead

Example

- Project 1 requirements and constraints
  1. Deadline and resources (time, personnel) are fixed
  2. Delivered functionality and quality can vary (though they affect the grade)
  3. Risks:
     1. Missing the deadline
     2. Technology problems
     3. Inadequate requirements
     4. Learning while doing
- Process model
  - All of these risks can be addressed to some extent by building some version of the product, then improving on it as time allows (software and docs.)
  - Technology risk requires building/finding software and trying it (prototyping)
  - Most forms of incremental development will address these

Project Planning and Management

Document Types and Purposes

- Management documents
  - Basis for **managerial control** of resources
    - Calendar time, skilled man-hours, budget
    - Other organizational resources
  - Project plan, WBS, Development schedule
  - Utility: supports resource allocation to meet time and budget constraints
    - allows managers to track actual against expected use of resources
- **Development documents**
  - **Basis for intellectual control of product content and quality**
  - **ConOps, Requirements (SRS), Architecture, Detail design, code, User's Guide, etc.**
  - **Utility: vehicles for making and recording development decisions**
    - **Allows developers to track decisions from stakeholder needs to implementation**

Project Plan

- Purpose: specifies how project resources will be organized to:
  - Create each deliverable
  - Meet quality goals
  - Address developmental goals (e.g., mitigate risk)
- Audience: should answer specific kinds of questions for different types of users, e.g.:
  - Customers: When will the product be delivered?
  - Stakeholders: What is the development approach? How does it address project risks?
  - Managers: When will tasks be completed? What is the current progress against the plan?
  - Developers: What should I be working on and when?

From Process to Plan

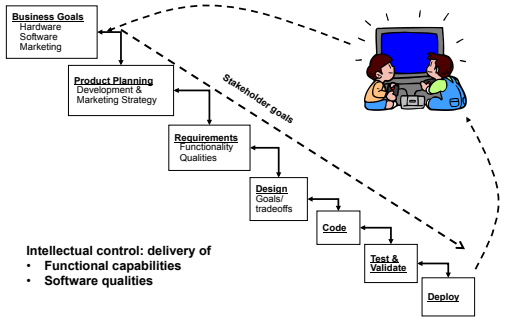
- Process manifests itself in the project plan
  - Process definition is an abstraction
  - Many possible ways of implementing the same process
- *Project plan makes process concrete*, it assigns
  - People to roles
  - Artifacts to deliverables and milestones
  - Activities to tasks over time
- Evolves as the project proceeds

Planning Tools

- Work Breakdown Structure: decompose tasks and allocate responsibilities
  - If incomplete, some tasks may not be done
  - If imprecise, people do not know exactly what to do
  - Without a complete set of tasks, schedules are unrealistic
- PERT charts: identify where ordering of tasks may cause problems
  - Represent precedence or resource constraints
  - Identify critical path
- Gantt Charts: method for visualizing project schedule (tasks, dependencies, timing, persons)
- Note that these help address problems our projects have encountered

Intellectual Control

Product Development Cycle



Intellectual control: delivery of
- **Functional capabilities**
- **Software qualities**

Document Types and Purposes

- **Management documents**
  - **Basis for project management (managerial control of resources)**
    - **Calendar time, skilled man-hours budget**
    - **Other organizational resources**
  - **Project plan, WBS, Development schedule**
  - **Use: allows managers to track actual against expected consumption of resources**
- Development documents
  - Basis for intellectual control
    - Used for making and communicating engineering decisions (requirements, design, implementation, verification, etc.)
    - Allows developers to track decisions from stakeholder needs to implementation
  - Basis for communicating decisions
  - Requirements, Architecture, Detail design, Reviews, Tests

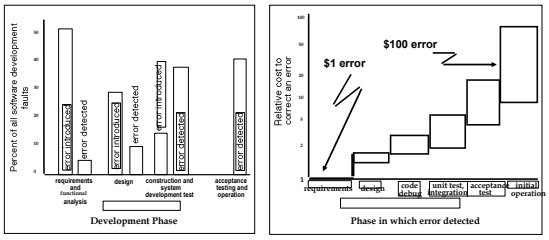
What is a “software requirement?”

- A description of something the software must do or property it must have
- The set of system requirements denote the problem to be solved and any constraints on the solution
  - Specifies “what” not “how”
  - Bounds the set of acceptable implementations

Importance of Getting Requirements Right

1. The majority of software errors are introduced early in software development

2. The later that software errors are detected, the more costly they are to correct



Requirements Phase Goals

- What does “getting the requirements right” mean in the systems development context?
- Only three goals
  1. Understand precisely what is required of the software
  2. Communicate that understanding to all of the parties involved in the development (stakeholders)
  3. Control production to ensure the final system satisfies the requirements
- Sounds easy but hard to do in practice, observed this and the resulting problems in projects
- Understanding what makes these goals difficult helps us understand how to mitigate the risks

What makes requirements difficult?

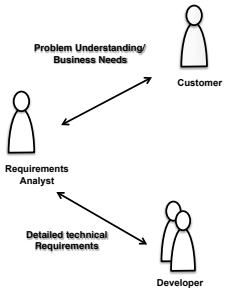
- Comprehension (understanding)
  - People don't (really) know what they want (…until they see it)
  - Superficial grasp is insufficient to build correct software
- Communication
  - People work best with regular structures, coherence, and visualization
  - Software's conceptual structures are complex, arbitrary, and difficult to visualize
- Control (predictability, manageability)
  - Difficult to predict which requirements will be hard to meet
  - Requirements change all the time
  - Together make planning unreliable, cost and schedule unpredictable
- Inseparable Concerns
  - Many requirements issues cannot be cleanly separated
  - Difficult to apply "divide and conquer," must make tradeoffs
- Implication: all the requirements goals are difficult to achieve, must be managed as a risks!

Requirements Communication (Specification)

- Many potential stakeholders using requirements for different purposes
  - Customers: the requirements document what should be delivered
  - Managers: provides a basis for scheduling and a yardstick for measuring progress
  - Software Designers: provides the "design-to" specification
  - Coders: defines the range of acceptable implementations
  - Quality Assurance: basis for validation, test planning, and verification
  - Also: potentially Marketing, regulatory agencies, etc.

Needs of Different Audiences

- Customer/User
  - Focus on problem understanding
  - Use language of problem domain
  - Technical if problem space is technical
- Development organization
  - Focus on system/software solutions
  - Use language of solution space (software)
  - Precise and detailed enough to write code, test cases, etc.



Documentation Approaches

- ConOps: informal requirements to describe the system's capabilities from the customer/user point of view
  - Answer the questions, "What is the system for?" and "How will the user use it?"
  - Tells a story: "What does this system do for me?"
  - Helps to use a standard template
- SRS: formal, technical requirements for development team
  - Purpose is to answer specific technical questions about the requirements quickly and precisely
  - Precise, unambiguous, complete, and consistent as practical

Scenario Analysis and Use Cases

- Common user-centered analysis method
- Requirements Elicitation
  - Identify stakeholders who interact with the system
  - Collect "user stories" - how people would interact with the system to perform specific tasks
- Requirements Specification
  - Record as use-cases with standard format
  - Use templates to standardize, drive elicitation
- Requirements verification and validation
  - Review use-cases for consistency, completeness, user acceptance
  - Apply to support prototyping
  - Verify against code (e.g., use-case based testing)

1 Brief Description

This use case describes how the Bank Customer uses the ATM to withdraw money to his/her bank account.

2 Actors

2.1 Bank Customer
2.2 Bank

3 Preconditions

There is an active network connection to the Bank.
The ATM has cash available.

4 Basic Flow of Events

1. The use case begins when Bank Customer inserts their Bank Card.
2. Use Case: Validate User is performed.
3. The ATM displays the different alternatives that are available on this unit. [See Supporting Requirement SR-xxx for list of alternatives]. In this case the Bank Customer always selects "Withdraw Cash".
4. The ATM prompts for an account. See Supporting Requirement SR-yyy for account types that shall be supported.
5. The Bank Customer selects an account.
6. The ATM prompts for an amount.
7. The Bank Customer enters an amount.
8. Card ID, PIN, amount and account is sent to Bank as a transaction. The Bank Consortium replies with a go/no go reply telling if the transaction is ok.
9. Then money is dispensed.
10. The Bank Card is returned.
11. The receipt is printed.

5 Alternative Flows

5.2 Wrong account

If in step 8 of the basic flow the account selected by the Bank Customer is not associated with this bank card, then

1. The ATM shall display the message "Invalid Account – please try again".

2. The use case resumes at step 4.|

Example Use Case

- Avoids design decisions
- References other use cases
- References more precise definitions where necessary
- Some terms need further definition (e.g. PIN)

Benefits and Drawbacks

- Use cases can be an effective tool for:
  - Eliciting user-group's functional requirements
  - Communicating to non-technical stakeholders
  - Creating initial test cases
  - Verifying expected behavior
- Generally inadequate for detailed technical requirements
  - Difficult to find specific requirements
  - Inherently ambiguous and imprecise
  - Cannot establish completeness or consistency
- True of all informal specification methods

Technical Specification

The SRS

The role of rigorous specification

Requirements Documentation

- Is a detailed requirements specification necessary?
- How do we know what "correct" means?
  - How do we decide exactly what capabilities the modules should provide?
  - How do we know which test cases to write and how to interpret the results?
  - How do we know when we are done implementing?
  - How do we know if we've built what the customer asked for (may be distinct from "want" or "need")?
  - Etc…
- Correctness is a *relation* between a spec and an implementation (M. Young)
  - Implication: until you have a spec, you have no standard for "correctness"

Technical Requirements

- Focus on developing a technical specification
  - Should be straight-forward to determine acceptable inputs and outputs
  - Can systematically check completeness consistency
- Provides
  - Detailed specification of precisely what to build
  - Design-to specification
  - Build-to specification for coders
  - Characterizes expected outputs for testers
- Little application in Project 1

Quality Requirements

Quality Requirement Types

- Avoid “functional” and non-functional" classification
- Behavioral Requirements – any requirements or constraints on the system's run-time behavior
  - Measurable qualities (safety, performance, fault-tolerance)
  - In theory all can be validated by observing the running system and measuring the results
- Developmental Quality Attributes - any constraints on the system's static construction
  - Maintainability, reusability, ease of change (mutability)
  - Measures of these qualities are necessarily relativistic (I.e., in comparison to something else

Behavioral and Developmental Requirements

Behavioral (observable)	Developmental Qualities
• Performance • Security • Availability • Reliability • Usability	• Modifiability(ease of change) • Portability • Reusability • Ease of integration • Understandability • Support concurrent development
Properties resulting from the behavior of components, connectors and interfaces that exist at run time.	Properties resulting from the structure of components, connectors and interfaces that exist at design time *whether or not they have any distinct run-time manifestation.*

Importance

- Quality requirements are as or more important to user acceptance than functional
  - Every system has critical quality requirements
  - The most frequent reason for user dissatisfaction
- Quality requirements are often implicit or assumed
  - E.g., response time, data integrity
- Must be explicit to be controlled
  - Implicit requirements cannot be communicated, tracked, verified, etc.
  - Left out at crunch time

Specifying Quality Requirements

- When using natural language, write *objectively verifiable* requirements when possible
  - Load handling: The system will support a minimum of 15 concurrent users while staying with required performance bounds.
  - Maintainability: “The following kinds of requirement changes will require changes in no more than one module of the system…”
  - Performance:
    - “System output X has a deadline of 5 ms from the input event.”
    - “System output Y must be updated at a frequency of no less than 20 ms.”

Requirements Validation and Verification

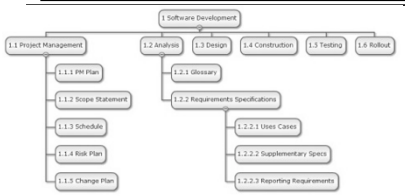
- Feedback-control for requirements
- Should answer two distinct questions:
  - Validation: “Are we building to the right requirements?”
  - Verification: “Are we building what we specified?”
- Validation requires going back to the stakeholders: can use many techniques
  - Review of specifications
  - Prototyping, software review
  - Use case walkthroughs
- Verification requires checking work products against specifications
  - Review
  - Testing
  - Formal modeling and analysis

Real meaning of “control”

- What does “control” really mean?
- Can we really get everything under control then run on autopilot?
- Rather control requires continuous feedback loop
  1. Define ideal
  2. Make a step
  3. Evaluate deviation from idea
  4. Correct direction or redefine ideal and go back to 2

End

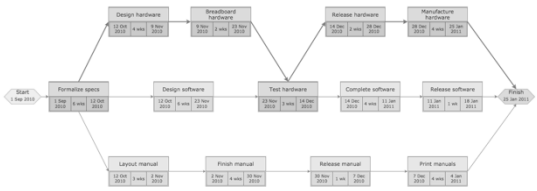
Work Breakdown Structure



1. Software Development
   1. Project Management
   2. Analysis
      1. Glossary
      2. Requirements Specification
         1. Use Cases
         2. Supplementary Specs…

Equivalent list format

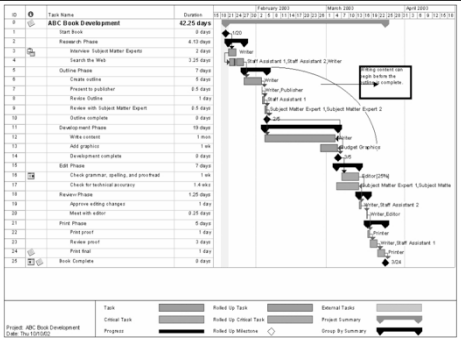
PERT Chart Example



- Which tasks can we start on?
- Which tasks can be done concurrently?
- Which tasks depend on which other tasks?
- *Critical Path*: which path has the longest duration?
  - Gives minimum length of project

http://www.conceptdraw.com/samples/project-chart

Example Gantt Chart



Teamwork and Group Dynamics

What do software developers do?

- Most time is not spent coding
- So how do they spend their time?
- IBM study (McCue, 1978):
  - 50% team interactions
  - 30% working alone (coding & related)
  - 20% not directly productive

-Technical excellence is not enough

Must understand how to work effectively in teams

Being a Good Team Member

- Attributes most valued by other team members
  - Dependability
    - When you say you'll do something, you do it
    - Correctly
    - On time
  - Carrying your own weight (doing a fair share of the work)
- People will overlook almost everything else if you do these

Consensus decision making

- Consensus is not counting votes
  - Democracy is 51% agreement
  - Unanimity is 100% agreement
- Consensus is neither
  - Everyone has their say
  - Everyone accepts the decision, even if they don't prefer it
  - It is "buying in" by group as a whole, including those who disagree
- Usually best approach for peer groups

Consensus takes time and work, but is worthwhile