Software Process

Overview

• What is software process?
• Examples of process models
• Unified Process (UP)
• Agile software development
Software Process

• Definition [Pressman]
  – a framework for the tasks that are required to build high-quality software.
  – to provide stability, control and organization to an otherwise chaotic activity

Code-and-Fix Process

• The first thing people tried in the 1950s
  1. Write program
  2. Improve it (debug, add functionality, improve efficiency, ...)
  3. GOTO 1

• Works for small 1-person projects and for some CS course assignments
Problems with Code-and-Fix

- Poor match with user needs
- Bad overall structure - No blueprint
- Poor reliability - no systematic testing
- Maintainability? What’s that?
- What happens when the programmer quits?

Code-and-Fix Process

From McConnell, After the Goldrush, 1999
A More Advanced Process

Examples of Process Models

- Waterfall model
- Prototyping model
- Spiral model
- Incremental model
Waterfall Model

• The “classic” process model since 1970s
  – Also called “software life cycle”

Waterfall Phases

• Analysis: Define problems
  – requirements, constraints, goals and domain concepts
• Design: Establish solutions
  – System architecture, components, relationship
• Implementation: Implement solutions
• Testing and integration: Check solutions
  – Unit testing, system testing
• Maintenance: the longest phase
Key Points of the Model

• The project goes through the phases sequentially
• Possible feedback and iteration across phases
  – e.g., during coding, a design problem is identified and fixed
• Typically, few or no iterations are used
  – e.g., after a certain point of time, the design is “frozen”

Waterfall Model Assumptions

• All requirements are known at the start and stable
• Risks (unknown) can be turned into known through schedule-based invention and innovation
• The design can be done abstractly and speculatively
  – i.e., it is possible to correctly guess in advance how to make it work
• Everything will fit together when we start the integration
Pros and Cons

• Pros: widely used, systematic, good for projects with well-defined requirements
  – Makes managers happy
• Cons:
  – The actual process is not so sequential
    • A lot of iterations may happen
  – The assumptions usually don’t hold
  – Working programs are not available early
    • High risk issues are not tackled early enough
  – Expensive and time-consuming

When would you like to use waterfall?

• Work for big clients enforcing formal approach on vendors
• Work on fixed-scope, fixed-price contracts without many rapid changes
• Work in an experienced team
Observation

• Top three reasons for at least partial failure projects
  – lack of user input
  – incomplete requirements, and
  – changing requirements

Prototyping Model

• Build a prototype when customers have ambiguous requirements
Key Points of the Model

• Iterations: customer evaluation followed by prototype refinement
• The prototype can be paper-based or computer-based
• It models the entire system with real data or just a few screens with sample data
• Note: the prototype is thrown away!

Pros and Cons

• Pros
  – Facilitate communication about requirements
  – Easy to change or discard
  – Educate future customers
• Cons
  – Iterative nature makes it difficult to plan and schedule
  – Excessive investment in the prototype
  – Bad decisions based on prototype
    • E.g., bad choice of OS or PL
When would you like to use prototyping?

- When the desired system has a lot of interactions with users

Spiral Model

- A risk-driven evolutionary model that combines development models (waterfall, prototype, etc.)
Spiral Phases

- **Objective setting**
  - Define specific objectives, constraints, products, plans
  - Identify risks and alternative strategies
- **Risk assessment and reduction**
  - Analyze risks and take steps to reduce risks
- **Development and validation**
  - Pick development methods based on risks
- **Planning**
  - Review the project and decide whether to continue with a further loop

What Is Risk?

- **Something that can go wrong**
  - People, tasks, work products
- **Risk management**
  - risk identification
  - risk analysis
    - the probability of the risk, the effect of the risk
  - risk planning
    - various strategies
  - risk monitoring
Risk Planning [Sommerville]

<table>
<thead>
<tr>
<th>Risk</th>
<th>Strategy</th>
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</thead>
<tbody>
<tr>
<td>Recruitment problems</td>
<td>Alert customer of potential difficulties and the possibility of delays, investigate buying-in-components</td>
</tr>
<tr>
<td>Defective components</td>
<td>Replace potentially defective components with bought-in components of known reliability</td>
</tr>
<tr>
<td>Requirements changes</td>
<td>Derive traceability information to assess requirements change impact, maximize information hiding in the design</td>
</tr>
<tr>
<td>Organizational financial problems/ restructuring</td>
<td>Prepare a briefing document for senior management showing how the project is making a very important contribution to the goals of the business</td>
</tr>
<tr>
<td>Underestimated development time</td>
<td>Investigate buying-in components, investigate the use of a program generator</td>
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Key Points of the Model

- Introduce risk management into process
- Develop evolutionary releases to
  - Implement more complete versions of software
  - Make adjustment for emergent risks
Pros and Cons

- **Pros**
  - High amount of risk analysis to avoid/reduce risks
  - Early release of software, with extra functionalities added later
  - Maintain step-wise approach with “go-backs” to earlier stages
- **Cons**
  - Require risk-assessment expertise for success
  - Expensive

When to use the model?

- Large and mission-critical projects
- Medium to high-risk projects
- Significant changes are expected
Incremental Model

- A sequential of waterfall models

Key Points of the Model

- Iterative: many releases/increments
  - First increment: core functionality
  - Successive increments: add/fix functionality
  - Final increment: the complete product
- Require a complete definition of the whole system to break it down and build incrementally
Pros and Cons

• **Pros**
  – Early discovery of software defects
  – Early delivery of working software
  – Less cost to change/identify requirements

• **Cons**
  – Constant changes ("feature creep") may erode system architecture

When to use the model?

• The requirements of the complete system are clear
• Major requirements must be defined while some details can evolve over time
• Need to get a product to the market early
Spiral model vs. incremental model

- Iterative models
  - Most projects build software iteratively
- Risk-driven vs. client-driven

Unified Process (UP)

- An example of iterative process for building object-oriented systems
  - Very popular in the last few years
  - By the same folks who develop UML
- It provides a context for our discussion of analysis and design
### Phases in UP

<table>
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<tr>
<th>Phase</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inception</td>
<td>preliminary investigation</td>
</tr>
<tr>
<td>Elaboration</td>
<td>analysis, design, and some coding</td>
</tr>
<tr>
<td>Construction</td>
<td>more coding and testing</td>
</tr>
<tr>
<td>Transition</td>
<td>beta tests and development</td>
</tr>
</tbody>
</table>

Each phase may be enacted in an iterative way, and the whole set of phases may be enacted incrementally.

### Iteration Length

- **Iteration should be short (2-6 weeks)**
  - Small steps, rapid feedback and adaptation
  - Massive teams with lots of communication - but no more than 6 months
- **Iterations should be timeboxed (fixed length)**
  - Integrate, test and deliver the system by a scheduled date
  - If not possible: move tasks to the next iteration
Reasons for Timeboxing

• Improve programmer productivity with deadlines
• Encourage prioritization and decisiveness
• Team satisfaction and confidence
  – Quick and repeating sense of completion, competency, and closure
  – Increase confidence for customers and managers

UP Disciplines

• Discipline: an activity and related artifact(s)
• Artifact: any kind of work product
  – Requirement modeling
    • requirement analysis + use-case models, domain models, and specs.
  – Design
    • design + design models
  – Implementation
    • code
Agile Software Development

• A timeboxed iterative and evolutionary development process
• It promotes
  – adaptive planning
  – evolutionary development,
  – incremental delivery
  – rapid and flexible response to change

Any iterative method, including the UP, can be applied in an agile spirit.

The Agile Manifesto

Kent Beck et al. 2001

• We are uncovering better ways of developing software by doing it and helping others do it. Through this work we have come to value:
  – Individuals and interactions over Processes and tools
  – Working software over Comprehensive documentation
  – Customer collaboration over Contract negotiation
  – Responding to change over Following a plan
Key Points of Agile Modeling

• The purpose of modeling is primarily to understand, not to document
• Modeling should focus on the smaller percentage of unusual, difficult, tricky parts of the design space
• Model in pairs (or triads)
• Developers should do the OO design modeling for themselves
• Create models in parallel
  – E.g., interaction diagram & static-view class diagram

Models are inaccurate

• Only tested code demonstrates the true design
• Treat diagrams as throw-away explorations
• Use the simplest tool possible to facilitate creative thinking
  – E.g., sketching UML on whiteboards
• Use “good enough” simple notation
Agile Methods

- Agile Unified Process (Agile UP)
- Dynamic systems development method (DSDM)
- Extreme programming (XP)
- Feature-driven development (FDD)
- Scrum

Agile UP

- Keep it simple
  - Prefer a small set of UP activities and artifacts
  - Avoid creating artifacts unless necessary
- Planning
  - For the entire project, there is only a high-level plan (Phase Plan), to estimate the project end date and other major milestones
  - For each iteration, there is a detailed plan (Iteration plan) created one iteration in advance
Pros and Cons

• Pros
  – Customer satisfaction by rapid, continuous delivery of useful software
  – Close, daily cooperation between business people and developers
  – Better software quality and lower cost

• Cons
  – People may lose sight of the big picture
  – Heavy client participation is required
  – Poor documentation support for training of new clients/programmers

When to use agile methods?

• Changing requirements
• Faster time to market and increased productivity
• Frequently used in start-up companies