CMSC 132:
Object-Oriented Programming II

Software Process Models

Department of Computer Science
University of Maryland, College Park
Overview

Software process models
- Waterfall
- Iterative

Choosing a software process model
- Level of understanding
- Cost of change
Software Process Models

Software methodology

- Codified set of practices
- Repeatable process for producing quality software

Software process model

- Methodology for organizing software life cycle
- Major approaches
  - Waterfall model
  - Iterative development
  - Formal methods
**Waterfall Model**

**Approach**
- Perform steps in order
- Begin new step only when previous step is complete
- Result of each step flow into next step

```
Problem specification
  ↓
Program design
  ↓
Selection of algorithms and data structures
  ↓
Coding and debugging
  ↓
Testing and verification
  ↓
Documentation and support
  ↓
Maintenance
```
Waterfall Model

Advantages

- Simple
- Predictable results
  - Software follows specifications
- Reasonable for small projects

Problems

- In real life
  - May need to return to previous step
  - Steps may be more integrated
  - Steps may occur at same time
- Unworkable for large projects
Iterative Software Development

Approach

- Iteratively add incremental improvements
- Take advantage of what was learned from earlier versions of the system
- Use working prototypes to refine specifications
Iterative Software Development

- **Goals**
  - Emphasize *adaptability* instead of predictability
  - Respond to changes in customer requirements

- **Examples**
  - Unified model
  - Agile software development
  - Extreme programming (XP)
Unified Model

Development divided into phases (iterations)

1. Inception
2. Elaboration
3. Construction
4. Transition

During each phase

- Multiple iterations of software development
- Development treated as mini-waterfalls
- Emphasis gradually shifts from specification to testing
Unified Software Life Cycle Model
Agile Software Development

Agile approach

- Based on iterative development
  - Short iterations (timeboxes) lasting 1-4 weeks
- Working software as principal measure of progress
  - Produced at end of each iteration
- Adds a more people-centric viewpoint
  - Face-to-face communication preferred
  - Co-locate programmers, testers, “customers”
- Relies on adapting to feedback rather than planning as the primary control mechanism
  - Less specification & documentation
Extreme Programming (XP)

- Prominent example of Agile methodology
  - Iterative, adaptive software development
- Describes set of day-to-day practices
  - Followed by managers & programmers
  - Intended to encourage a set of values
- Appropriate for environments with
  - Small teams
  - Rapidly-changing requirements
Extreme Programming Values

- Communication
  - Rapidly building & disseminating institutional knowledge among programming team

- Simplicity
  - Implement simplest code needed by customer without emphasis on future versions

- Feedback
  - From testing, team members, customers

- Courage
  - Willingness to rewrite / refactor software to add or change features
Extreme Programming Practices

- Pair programming
  - Pairs of programmers combine software development efforts at one computer
  - Especially useful for novice programmers

- Test-driven development
  - Tests are designed first, before writing software

- Continuous integration
  - Tests performed throughout development process

- On-site customer
  - Customer available at all times to answer questions
Formal Methods

- Mathematically-based techniques for
  - Specification, development, and verification
  - Software and hardware systems

- Intended for high-integrity systems
  - Safety
  - Security

- Levels
  0 – Informal implementation of formal specifications
  1 – Formal code development & verification
  2 – Theorem prover to ensure correctness
Choosing A Software Model

- Which software life cycle model is appropriate?
- For class programming projects
  - Code and test probably suffices
  - But software in real world not like class projects
- Some big questions
  - Do you understand what you are trying to build?
  - What is the cost of change?
  - How many people have to interact with the design?
  - How easy is it to get the entire thing in your head?
Do You Understand The Problem?

In many cases, the things we want software to do are not well understood

Examples

- Provide a web interface for student applications
- Allow users to view and manipulate photographs
- Build a better search engine

Hard to understand constraints / interactions

May have to build prototype

To understand how users can effectively use it
What Is The Cost Of Change?

Possible situation

- Most coding already complete
- Realize need to change something
  - In the design
  - Or even the requirements

How expensive is that?

- If hugely expensive
- Better get requirements & design right
  - Before completing too much code
Has The Cost Of Change Changed?

Some people believe

Recent software development techniques have substantially reduced cost of change

Possible reasons

Safer programming languages
  E.g., not C/C++/assembly language

Object-oriented design & programming

Test-driven development
Sometimes, Change Is Still Expensive

Expensive to change software that

- Is key nexus in a large system
  - Affects many lines of code
- Interacts with co-designed hardware
  - May need to change hardware design
- Interacts with software being developed externally
  - Can’t easily change API once published
How Many People Interact With Its Design?

People interacting with software design

- Part of the cost of change
  - Need to alert / consult people on design change
- Design changes that interact with a lot of people
  - Expensive and need to be minimized
  - Try to get design choices right early and documented
How Easy Is Software To Understand?

- When building and developing software, you need to understand it (at least, parts of it)
  - For 100 lines of code, just read the code
  - Doesn’t work for 100,000 lines of code
- Need to have ways of documenting the requirements & design at a higher level