An Overview of Software Development

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What are these circles in this Software Product?
Products in other disciplines

- Homebuilding
  - Architect sketches
  - Blueprints
  - Appliance Manuals
  - Violation reports
  - ??
Products in other disciplines

• Homebuilding
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  – ??
• Legislation

• Homebuilding
  – Architect sketches
  – Blueprints
  – Appliance Manuals
  – Violation reports
  – ??
• Legislation
  – Hearings
  – Laws
  – Bureaucracies
  – Court cases
  – ??
Some Key Features of These Products

- Problem enunciation, understanding
  - What is the problem to be solved?
- Solution formulation
  - How might the problem be solved?
- Solution reduction to practice
  - How will the problem actually be solved?
- Solution implementation
  - The actual solution to the problem

- Interconnections among all of these
- Evidence of consistency
- Intuition (?) about what makes them “good”
- Schedules and development histories
Some Key Features of These Products

- Problem enunciation, understanding (requirements)
  - What is the problem to be solved?
- Solution formulation (architecture)
  - How might the problem be solved?
- Solution reduction to practice (design)
  - How will the problem actually be solved?
- Solution implementation (coding)
  - The actual solution to the problem
- Interconnections among all of these
- Evidence of consistency (analysis/testing)
- Intuition (?) about what makes them “good”
- Schedules and histories (development process)

How to represent all of this?
How to Represent All of This?

- The artifacts/entities/components
  - The different types
  - Their decompositions
  - Their continued change, growth
- The relations among them
  - Desired
  - Actual
- Their time-varying nature

Software Artifacts as Instances of Types

- Example: A requirement specification
  - A structure of instances of types
  - Probably hierarchical
  - Different types for different kinds of requirements
- Functional Requirement
  - A DFG?
  - An FSA?
- Timing requirement
  - A first order logic specification?
  - A Petri Net?
- Robustness requirement
  - An FSA?

How to decide which to use?
Most of the rest of the course will examine the various key types of software product components and try to define them as (software) types.

Relations

• Many software artifacts are relations
  – DFG, CFG
• Some relations are over types (e.g. DFG hierarchy relation)
• They define, correctness, “well-formedness”
• Are the basis for evaluation
  – Are all of the instances of a relation properly related to each other?
• Are used in evolution
  – If not, then remedying improper relations becomes a goal of evolution
Some Examples of “Relations”

- Executing this code must meet this requirement
- This code must conform to that design element
- This compiled code came from this compiler
- This design element addresses those requirements

- These lower level requirements are elaborations of these higher level requirements
- This is the date by which that test must be passed
- Component invocations conform to component abstract interface specifications
- Documentation describes the actual system
- ETC.....
Much of the rest of the course will examine the ways in which consistency is defined and determined through the use of relation specifications.
Much of the rest of the course will also be focused on the ways in which these artifacts are made and interconnected.

If the *product* is this complicated, then it probably takes a complicated *process* to make it.

How to define the process too?

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**Simple example of how to develop SW:**

The Waterfall Model

- Requirements
- High-Level Design
- Low-Level Design
- Code
- Test
Problems with the Waterfall

- It trivializes the process
  - No loops
  - No decomposition
- And things do not necessarily have to happen in this order either

OK, so here are some loops: Rework between phases

Requirements → High-Level Design → Low-Level Design → Code → Test

Requirements → High-Level Design

Requirements → Low-Level Design

Requirements → Code
All right, all right, more loops

Still at Least One More Problem: Need both Control and Data Flow

- Which did we just see?
  - Could have been either (both?)
- DFGs lack control flow information
- CFGs lack data flow information
- When to do what?
- What really follows what, and when?
- Etc.
So how about this version?

Leaves Key Questions Unanswered

Where does output go?

What to do when reviews fail?

What causes this rework?

What portion of this activity should be done?

How do we break this cycle?
Iteration in process

- Loops somehow seem inherent in software development
- Waterfall Diagram CFG showed loops with no useful semantics
  - Clearly inadequate
- Putting in loops made things complicated
  - And less clear

What’s the Problem with Loops?

- Loops are hard to control
- What changes on each iteration
  - And what does not
- When to stop looping
  - And how?
- Familiar problems in application software
- Also present in software processes
What’s the Problem with Loops?

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Question: What are the loops for?

The Shewhart/Deming Cycle:
The Shewhart/Deming Cycle: Each Iteration Yields Improvement

The Shewhart/Deming Cycle: Each Iteration Yields Improvement --of some kind
W. Edwards Deming

- Father of modern manufacturing quality
  - Bell Labs in 1940s
  - Appreciated first by Japan
  - Now universally appreciated
- Popularized “Plan-Do-Check-Act”
- Credits PDCA to Walter Shewhart
  - Just the “scientific method”? (Francis Bacon in 17th Century)

Looping in Software Development Should Be for Risk Reduction (?)

- What are the risks?
  - Failing to satisfy stakeholders
  - Who are the stakeholders, what are their stakes? What are the costs of failing a stakeholder?
  - What are the costs of being sure you don’t fail?
- Waterfall does not suggest or support this idea
- More contemporary development approaches focus on this issue better
- E.g. Boehm’s Spiral Model makes these issues clearer
Some More Contemporary Software Development Approaches

- Boehm’s Spiral Model
- Kruchten’s RUP (Rational Unified Process) Model
- Agile Models
  - e.g. Scrum
- Flexible Models
  - e.g. Process Programming

Boehm's Spiral Model
Abstract Spiral Model

Cost (cumulative)
determine objectives, alternatives, constraints
evaluate alternatives identify, resolve risks
Review
plan next phases
develop, verify next level product

Different Traversals of the Spiral Model to address different risks

application reqmts = low risk
budget, schedule = high risk

stable appl. reqmts & budget
errors = high risk

application reqmts = high risk
budget, schedule = low risk
And Yield Some New Approaches and Some Old Ones

The Waterfall

No focus in risk, no risk management
More Realistic Waterfall

- Recognition of feedback loops
  - Confined to successive stages
- “Build it twice”
  - Early prototyping

The beginnings of risk management

Reuse Based Development

New Process

Requires data store semantics

Reduce risk by using things proven in past use

Repository
**"Throwaway" prototyping**

Create a history of past use as part of the process to get a firm grip in risk issues in order to control them better.

**Evolutionary prototyping**

Similar to previous. Difference is the Scale of the prototype.
The Rational Unified Process

Use UML to define the process. This is a Message Sequence Diagram

- Architect
  - Architectural Analysis
  - Describe
  - Concurrency
  - Distribution
  - Review the Architecture
  - Architecture Reviewer

- Designer
  - Use-Case Analysis
  - Describe
  - Design
  - Review the Design
  - Design Reviewer

- Database Designer
  - Class Design
  - Describe
  - Design
  - Review the Design
  - Design Reviewer

Concurrency
Roles for agents
Not as phase-sequential
Many new software process ideas

• Some add many details to abstract spiral model
• Some reject “waterfall-based” approaches
  – Too “heavyweight”
  – Is that exact sequence of steps always necessary?
  – Need for agility
• The rise of “agile methods”, “extreme programming”…

Some Extreme Programming (XP) Examples

• Test-first programming
• Pair programming
• Scrum
• Etc.

More on these later
The Scrum: No Sequential Phases

- Software development in a sequence of “sprints”
  - Usually 30 sprints
- Each sprint lasts a day
- Sprint starts with a short meeting
  - Every team member has 2-3 minutes
- Scrum starts with overall goal-setting
  - A “burndown list”
- Scrum ends with evaluation
  - And planning for next scrum
- Main goals
  - Empower the team
  - “Time boxing” to keep things from taking too long
  - Risk mitigation

Representations of Software Development Processes

- We have just seen a few attempts
  - DFGs
  - CFGs
  - UML
  - Combinations
- Could have seen FSMs, Petri Nets.
- Software processes are very complex, though
  - Require a great deal of modeling semantics
- Maybe too complex for pictures?
Need a focus on process in order to complement our coming focus on product components

Being Precise About Processes

- Processes are REAL entities
- Important to define them
  - Completely
  - Clearly
  - Precisely
- For all relevant stakeholders
  - Developers
  - Customers
  - Managers
  - Regulators
  - Etc.
Processes as Software

• Consist of:
  – Process Requirements, the basis for
    » Process design, evaluation and improvement
  – Process Specification/Modeling/Design
    » Support for conceptualization, visualization
  – Process Code
    » Provides rigor and complete details
    » For for execution and tool integration
  – Process Analysis, Measurement, and Evaluation
    » Basis for....
  – Process Maintenance (Improvement)
• Develop processes using a process development process

Summary

• Software products are
  – Large, complex, tightly interconnected
  – Built by processes
• Software processes are
  – Products too
• Processes and Products each contain the other
• Processes and Products are built out of the same sort of material
As we define software products as instances of types, we will also define the processes by which they are developed and related to each other by defining the processes for doing these things.

Process Representation

- Who are the stakeholder groups for process representations?
  - Developers
  - Managers
  - Customers
- For Microprocess?
  - Developers and Managers
- What representation notation?
  - Need more details and rigor
  - Can be more technical, formal
- Diagrams could be OK for customers
  - Would need to be consistent with formal notations