Engineering 7893
Software Engineering
Software Process

Dennis Peters

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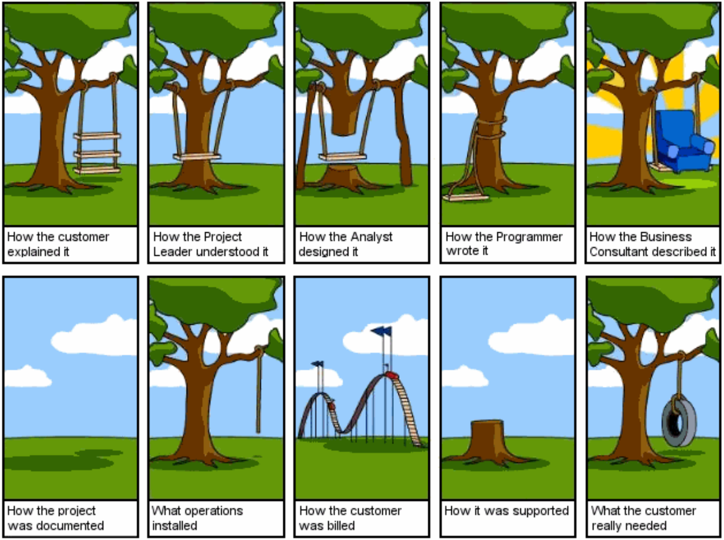
Software Engineering?



Engineering Process

We need to understand the steps that take us from an idea to a product.

- What do we do?
- In what order do we do it?
- How do we know when we're finished each step?

Production process

Typical steps in production process for any engineering project:

1. Requirements analysis — what problem are we to solve?
2. Design — how will we solve the problem?
3. Analysis — will our proposed solution solve the problem?
4. Implementation/construction — build the solution.
5. Validation — did we solve the problem (and will the customer buy it)?
6. Production — make copies of the product.
7. (Maintenance — make sure the solution keeps running.)

Is Software Different?

- Requirements are less stable.
- Nature (physics) plays a smaller role.
  - Doesn't (necessarily) fail in predictable ways.
  - Interpolation and extrapolation are rarely valid.
- No obvious natural decomposition.
- Complexity can be very high.
- Production (not implementation) is trivial.

"Traditional" Software Process

1. Requirements — describe "what" not "how"

   Analysis/elicitation What does the client really want?

   Specification Precisely describe the behaviour of the system.

2. Design

   Architectural design — what classes/components/modules will make up the system?

   - What role does each play?
   - What are its relationships (interactions, sub-classing, associations) with other modules?
   - What is its interface (including behaviour)? Abstract: independent of the implementation.
   - How can it be tested?

   Module design — how will each module be implemented.

3. Implementation — write the code.

Traditional Software Process (cont'd)

4. Verification
   - Unit test — behaviour of each module.
   - Integration test — interaction between modules.
   - System test — behaviour of the whole system.
5. Maintenance — modify the system.

- Each phase results in a product (document, code), which is the input to the next phase.
- If a phase is carried out rigorously, its product can be verified against the products of the previous phase(s) (analysis).
- Validation (Is this what the customer wants?) can be carried out early and after each phase.

When does the “Traditional” Process work well?

- Large teams — Components can be reasonably worked on in parallel.
- Few unknowns
  - Requirements are stable.
  - Technology is well known.
  - The team has solved similar problems before.
- Implementation and design are clearly distinct tasks.
- Implementation is a significant portion of development.
- Components can be effectively tested independently.

Incremental/Unified/Spiral Software Development

- Software system is developed through a sequence of short, fixed length (e.g., four week) increments.
  - Each includes requirements analysis, design, implementation, testing
  - The endpoint of each increment is a **functioning system**.
  - You can objectively determine if you've met the goals of the increment by the **behaviour** of the system.
  - Usually all behaviour of previous increments is also exhibited in later increments — there is progress towards the final goal.
- Documents are updated as part of each increment so they remain accurate. (live documents)
- Having an executable system makes it possible to get early and frequent feedback (validation).
- Feedback allows the design to be adapted as requirements are better understood or change.

How to plan for and execute incremental development

- Identify a set of distinct system behaviours (use cases).
- Assign each system behaviour to a particular increment.
- Candidates for early increments:
  - Highest priority (from the customer's point of view).
  - Highest risk (i.e., least well understood).
- Focus on what is needed for the current increment only (if it's not needed in this increment, *then don't do it*).
- Constantly track progress
  - If it looks like you won't meet a target date, drop behaviour rather than move the date.

When and Why to use Incremental Development

- Requirements are not well understood.
  - Developers get a better understanding by solving parts of the problem.
  - Users can give feedback on early increments.
- Technological uncertainty.
  - Early increments used to test if/how well technology is working to solve the problem.
- Schedule uncertainty.
  - Lack of experience makes it difficult to know how long it will take to do some parts.
  - Constant reflection makes adjusting the schedule easy.

When and Why (cont'd)

- Design/interface uncertainty.
  - Constant integration ensures that interfaces are understood.
- Important to deliver something quickly.
  - Time to market can be critical in some industries.
  - Gives management/customers confidence that progress is happening.
- Small team.
  - Parallel development of components isn't feasible.
  - Directs energy, avoids "thrashing."

Common mistakes

- An actual progress report from a previous student:

  > *"Increment 1 is 80% complete, increment 2 is 50% complete and increment 3 is 20% complete."*

  - This student clearly missed the point.
  - Each increment should be finished before the next is started.
- Failure to refactor.
  - At each increment consider the design and how it can evolve into the next increment.
  - If it isn't right for the next increment fix it **now** before it becomes an albatross around your neck.

Mistakes (cont'd)

- Focusing on components rather than behaviour.
  - Increments are defined by the behaviour they deliver, not the development that goes into them.
  - Keep your eyes on the bottom line (behaviour), not the components.
- Over design.
  - There is a strong tendency to want to make an "elegant design" (e.g., more flexible, configurable . . .).
  - The best designs are the simple designs (KISS = Keep It Simple, Stupid).
- Failure to make a plan and communicate it.
  - Write down what behaviour is in each increment.
  - Make sure everybody has the plan.
  - Keep the plan current.

Software Qualities: Exernal

Qualities: What makes good software?
External qualities: What the user cares about.

- Usefulness — does it do what the user wants?
- Performance — speed, size.
- Correctness — does it meet its specification? (assumes precise specification)
- Reliability — does it do what the user wants most of the time?
- Robustness — does it respond well to error/failures of other systems?
- Usability — is it easy to use?
- Interoperability — does is conform to relevant standards/formats etc.?
- User documentation.

Software Qualities: Internal

What future developers will care about. Attributes of source code and documentation.

- Correctness — internal documentation consistent with itself and the code.
- Changeability — Can the most likely changes be made easily? Can other changes be made reasonably?
- Understandability — Is code & documentation understandable?
- Reusability — Can components be reused in other projects?

Software Qualities: Process

What managers care about.

- Cost — production and maintenance.
- Timeliness — When will it be ready?
- Traceability — Can the progress of the production be monitored?

Principles to achieve quality

Rigour/Formality

- Precision and exactness in descriptions and processes.
- Software is only correct when it is clear what it means to be correct.
- Should not inhibit creative process—sketch then design.
- *Formal* means that content and meaning (syntax and semantics) are governed by mathematical laws.

Separation of Concerns

- Time: concentrate on different aspects of system at different times.
- Qualities: e.g., verify correctness without considering efficiency.
- Views: Choose appropriate technique for examining different aspects of system (e.g., class diagram vs. interaction diagram).
- Components: modularity.

Quality Principles (cont'd)

Modularity (a.k.a., classes)

- Simplify a difficult task by breaking it into smaller components.
- Correct parts imply a correct whole.
- Keep each part simple.
- High *cohesion* — all elements of the same module are strongly related.
- Low *coupling* — elements in a module do not depend heavily on elements in other modules (except what is in the interface).

Abstraction

- Hide details to enable understanding (separation of concerns)
- The interface of a component is more simple than its implementation.

Quality Principles (cont'd)

Anticipation of change

- Change is inevitable and often predictable.
- Encapsulate anticipated changes in modules (classes).
- Unanticipated changes ruin modularity.
- Unanticipated changes will be much harder to get right.

Incrementality

- Identify useful subsets of system.
- Get something running early and keep it running.