CSE 331
Software Design & Implementation

Hal Perkins

Autumn 2013

System Integration and Software Process

(slides by Mike Ernst)

Outline

Architecture

Tools: Build tools and version control

Tools: Bug tracking

Scheduling

Implementation and testing order

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Architecture

An architecture describes a partitioning of the system

- It indicates dependences on, and data flow between, modules

A good architecture ensures that

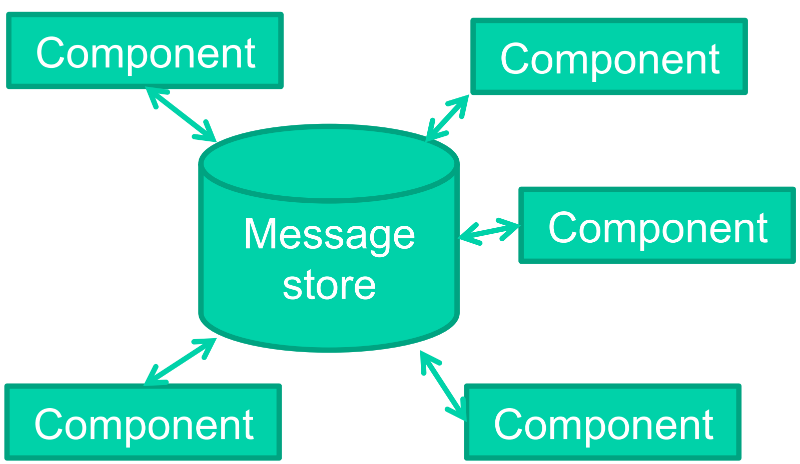
- Work can proceed in parallel
- Progress can be closely monitored
- The parts combine to provide the desired functionality

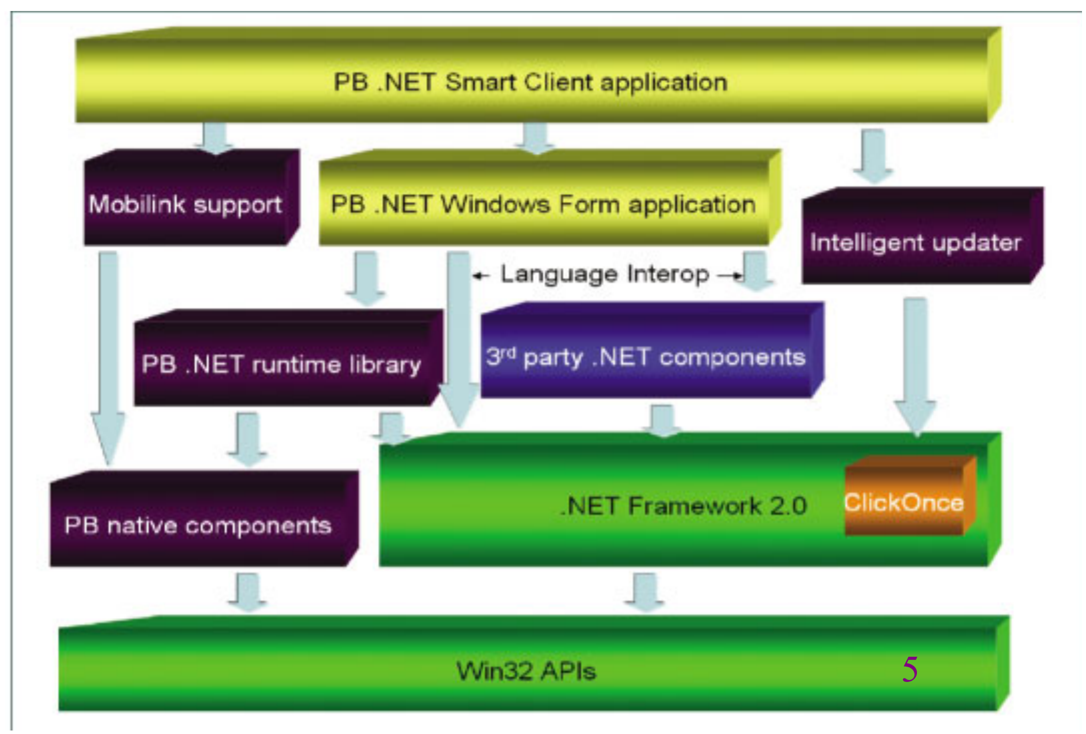
Example architectures

Pipe-and-filter (think: iterators)

Layered (think: levels of abstraction)

Blackboard (think: callbacks)





A good architecture allows:

Scaling to support large numbers of ______

Adding and changing features

Integration of acquired components

Communication with other software

Easy customization

- Ideally with no programming
- Turning users into programmers is good

Software to be embedded within a larger system

Recovery from wrong decisions

- About technology
- About markets

System architecture

- Have one!
- Subject it to serious scrutiny
  - At relatively high level of abstraction
  - Basically lays down communication protocols
- Strive for simplicity
  - Flat is good
  - Know when to say no
  - A good architecture rules things out
- Reusable components should be a design goal
  - Organizational mission is not the same as the project
  - Build your organization as well as the project
  - Software is capital
  - This will not happen by accident

Temptations to avoid

- Avoid featuritis
  - Costs under-estimated
    - Effects of scale discounted
  - Benefits over-estimated
    - A Swiss Army knife is rarely the right tool
- Avoid digressions
  - Infrastructure
  - Premature tuning
    - Often addresses the wrong problem
- Avoid quantum leaps
  - Occasionally, great leaps forward
  - More often, into the abyss

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Build tools

Building software requires many tools. Examples:

- Java compiler, C/C++ compiler, GUI builder, Device driver build tool, InstallShield, Web server, Database, scripting language for build automation, parser generator, test generator, test harness

Reproducibility is essential

System may run on multiple devices

- Each has its own build tools

Everyone needs to have the same toolset!

- Wrong, missing tool can drastically reduce productivity

Hard to switch tools in mid-project

Version control (source code control)

A version control system supports:

- Collecting work (code, documents) from all team members
- Synchronizing all the team members to current source
- Let multiple teams make progress in parallel
- Manage multiple versions, releases of the software
- Help identify regressions

Example tools:

- Subversion (SVN), Mercurial (Hg), Git

Policies are even more important

- When to check in, when to update, when to branch and merge, how builds are done
- Policies need to change to match the state of the project

Always diff before you commit

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Bug tracking

An issue tracking system supports:

- Tracking and fixing bugs
- Identifying problem areas and managing them
- Communicating between team members
- Track regressions and repeated bugs

Any medium to large size project requires bug tracking software

Example tools:

- Bugzilla, Flyspray, Trac, hosted tools (Sourceforge, Google Code, GitHub)

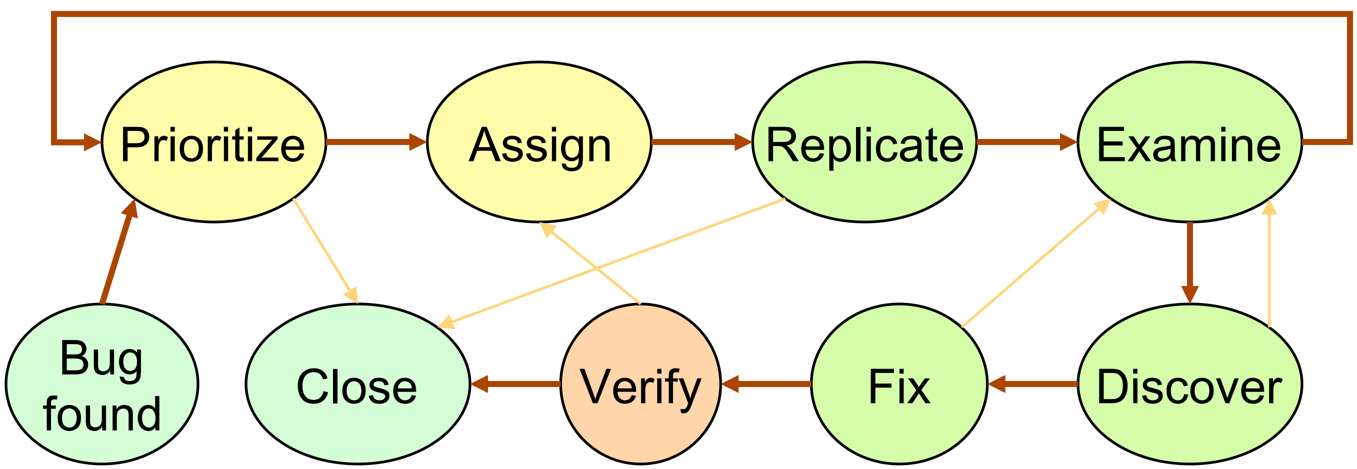
Bug tracking

Need to configure the bug tracking system to match the project

- Many make the system too complex to be useful

A good process is key to managing bugs

- Need an explicit policy that everyone knows, follows, and believes in



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"More software projects have gone awry for lack of calendar time than for all other causes combined."

-- Fred Brooks, *The Mythical Man-Month*

Three central questions of the software business

3. When will it be done?
2. How much will it cost?
1. When will it be done?

Estimates are almost always too optimistic

Estimates reflect what one wishes to be true

We confuse effort with progress

Progress is poorly monitored

Slippage is not aggressively treated

Scheduling is crucial but underappreciated

- Scheduling is underappreciated
  - Made to fit other constraints
- A schedule is needed to make slippage visible
  - Must be objectively checkable by outsiders
- Unrealistically optimistic schedules are a disaster
  - Decisions get made at the wrong time
  - Decisions get made by the wrong people
  - Decisions get made for the wrong reasons
- The great scheduling paradox
  - Everything takes twice as long as you think
  - ***… even if you know that it will take twice as long as you think***

Effort is not the same as progress

Cost is the product of workers and time

- Easy to track

Progress is more complicated, and hard to track

People don't like to admit lack of progress

- Think they can catch up before anyone notices
- Not usually possible

Design the process and architecture to facilitate tracking

How does a project get to be one year late?

One day at a time

It's not the hurricanes that get you

It's the termites

- Tom missed a meeting
- Mary's keyboard broke
- The compiler wasn't updated
- …

If you find yourself ahead of schedule

- Don't relax
- Don't add features

Controlling the schedule

First, you must have one

Avoid non-verifiable milestones

- 90% of coding done
- 90% of debugging done
- Design complete

100% events are verifiable milestones

- Module 100% coded
- Unit testing successfully complete

Need critical path chart (Gantt chart, PERT chart)

- Know effects of slippage
- Know what to work on when

Milestones

Milestones are critical keep the project on track

- Policies may change at major milestones
- Check-in rules, build process etc.

Some typical milestones

- Design complete
- Interfaces complete / feature complete
- Code complete / code freeze
- Alpha release
- Beta release
- Release candidate (RC)
- FCS (First Commercial Shipment) release

Dealing with slippage

- People must be held accountable
  - Slippage is not inevitable
  - Software should be on time, on budget, and on function
- Four options
  - Add people – startup cost ("mythical man-month")
  - Buy components – hard in mid-stream
  - Change deliverables – customer must approve
  - Change schedule– customer must approve
- Take no small slips
  - One big adjustment is far better than three small ones

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How to code and test your design

You have a design and architecture

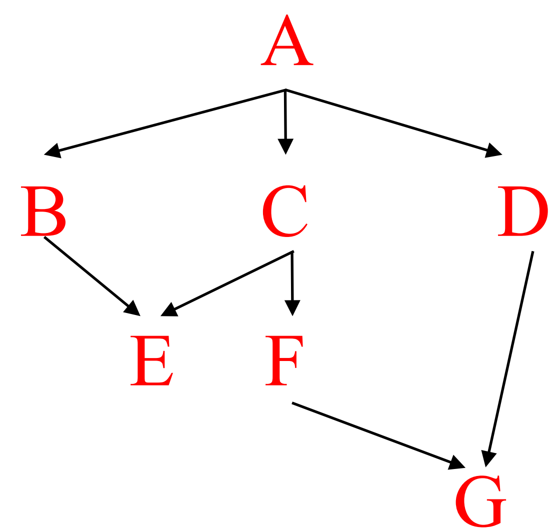
- Need to code and test the system

Key question, what to do when?

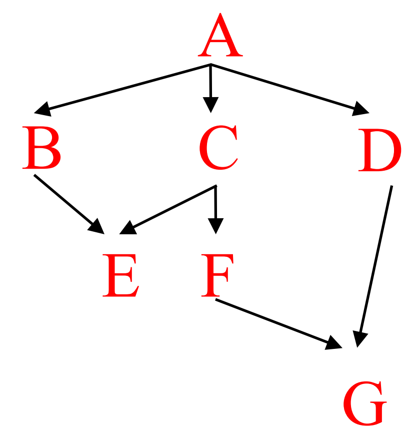
- We'll assume an incremental development model

Suppose the system has this module dependency diagram

- In what order should you address the pieces?



Bottom-up implementation



Implement/test children first

For example: G, E, B, F, C, D, A

First, test G stand-alone (also E)

Generate test data as discussed earlier

Construct drivers

Next, implement/test B, F, C, D

No longer unit testing: use lower-level modules

A test of module M tests:

whether M works, and

whether modules M calls behave as expected

When a failure occurs, many possible sources of defect

Integration testing is hard, irrespective of order

Building drivers

- Use a person
  - Simplest choice, but also worst choice
  - Errors in entering data are inevitable
  - Errors in checking results are inevitable
  - Tests are not easily reproducible
    - Problem for debugging
    - Problem for regression testing
  - Test sets stay small, don't grow over time
  - Testing cannot be done as a background task
- Better alternative: Automated drivers in a test harness

Test harnesses

Goals

- Increase amount of testing over time
- Facilitate regression testing
- Reduce human time spent on testing

Take input from a file

Call module being tested

Save results (if possible)

- Including performance information

Check results

- At best, is correct
- At worst, same as last time

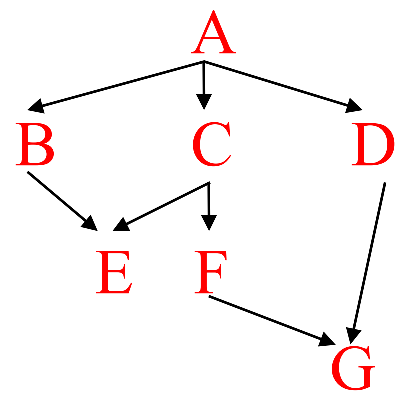
Generate reports

Regression testing

Ensure that things that used to work still do
- Including performance
- Whenever a change is made

Knowing exactly when a bug is introduced is important
- Keep old test results
- Keep versions of code that match those results
- Storage is cheap

Top-down testing



Implement/test parents (clients) first

- Here, we start with A

To run A, build stubs to simulate B, C, & D

Next, choose a successor module, e.g., B

- Build a stub for E
- Drive B using A

Suppose C is next

- Can we reuse the stub for E?

Implementing a stub

- Query a person at a console
  - Same drawbacks as using a person as a driver
- Print a message describing the call
  - Name of procedure and arguments
  - Fine if calling program does not need result
    - This is more common than you might think!
- Provide canned or generated sequence of results
  - Very often sufficient
  - Generate using criteria used to generate data for unit test
  - May need different stubs for different callers
- Provide a primitive (inefficient & incomplete) implementation
  - Best choice, if not too much work
  - Look-up table often works
  - Sometimes called “mock objects”

Comparing top-down and bottom-up

Criteria

- What kinds of errors are caught when?
- How much integration is done at a time?
- Distribution of testing time?
- Amount of work?
- What is working when (during the process)?

Neither dominates

- Useful to understand advantages/disadvantages of each
- Helps you to design an appropriate mixed strategy

Catching errors

Top-down tests global decisions first

- E.g., what system does
- Most devastating place to be wrong
- Good to find early

Bottom-up uncovers efficiency problems earlier

- Constraints often propagate downward
- You may discover they can't be met at lower levels

Amount of integration at each step

- Less is better
- Top-down adds one module at a time
  - When error detected either
    - Lower-level module doesn’t meet specification
    - Higher-level module tested with bad stub
- Bottom-up adds one module at a time
  - Connect it to multiple modules
  - Thus integrating more modules at each step
  - More places to look for error

Distribution of testing time

- Integration is what takes the time
- Bottom-up gets harder as you proceed
  - You may have tested 90% of code
    - But you still have far more than 10% of the work left
  - Makes prediction difficult
- Top-down more evenly distributed
  - Better predictions
  - Uses more machine time
    - In business environments this can be an issue

Amount of work

Always need test harness

Top-down

- Build stubs but not drivers

Bottom-up

- Build drivers but not stubs

Stubs are usually more work than drivers

- Particularly true for data abstractions

On average, top-down requires more non-deliverable code

- Not necessarily bad

What components work, when?

Bottom-up involves lots of invisible activity

- 90% of code written and debugged
- Yet little that can be demonstrated

Top-down depth-first

- Earlier completion of useful partial versions

One good way to structure an implementation

- Largely top-down
  - But always unit test modules
- Bottom-up
  - When stubs are too much work
  - Low level module that is used in lots of places
  - Low-level performance concerns
- Depth-first, visible-first
  - Allows interaction with customers, like prototyping
  - Lowers risk of having nothing useful
  - Improves morale of customers and programmers
    - Needn't explain how much invisible work done
    - Better understanding of where the project is
    - Don't have integration hanging over your head