System integration and software process

CSE 331

University of Washington

Outline

- Architecture
- Tools: Build tools and version control
- Tools: Bug tracking
- Scheduling
- Implementation and testing order

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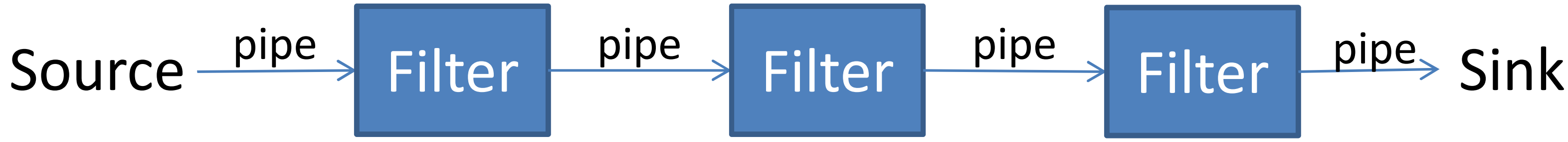
Architecture

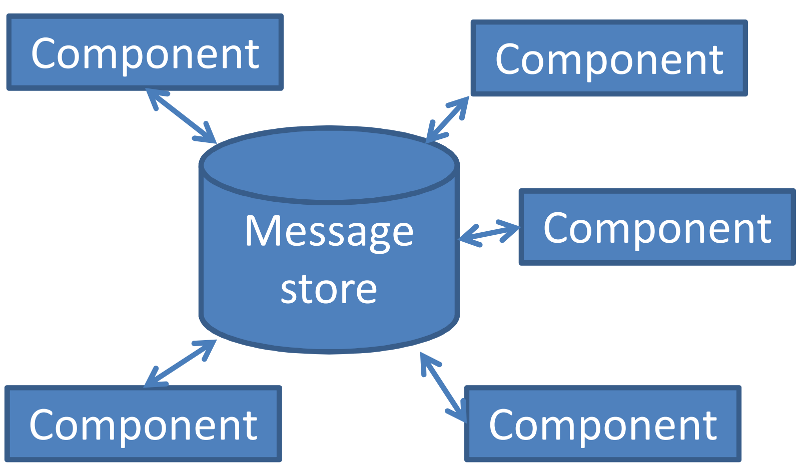
- An architecture describes a partitioning of the system
  - It indicates dependences on, and data flow between, modules
- A good architecture ensures that
  - Work can proceed in parallel
  - Progress can be closely monitored
  - The parts combine to provide the desired functionality

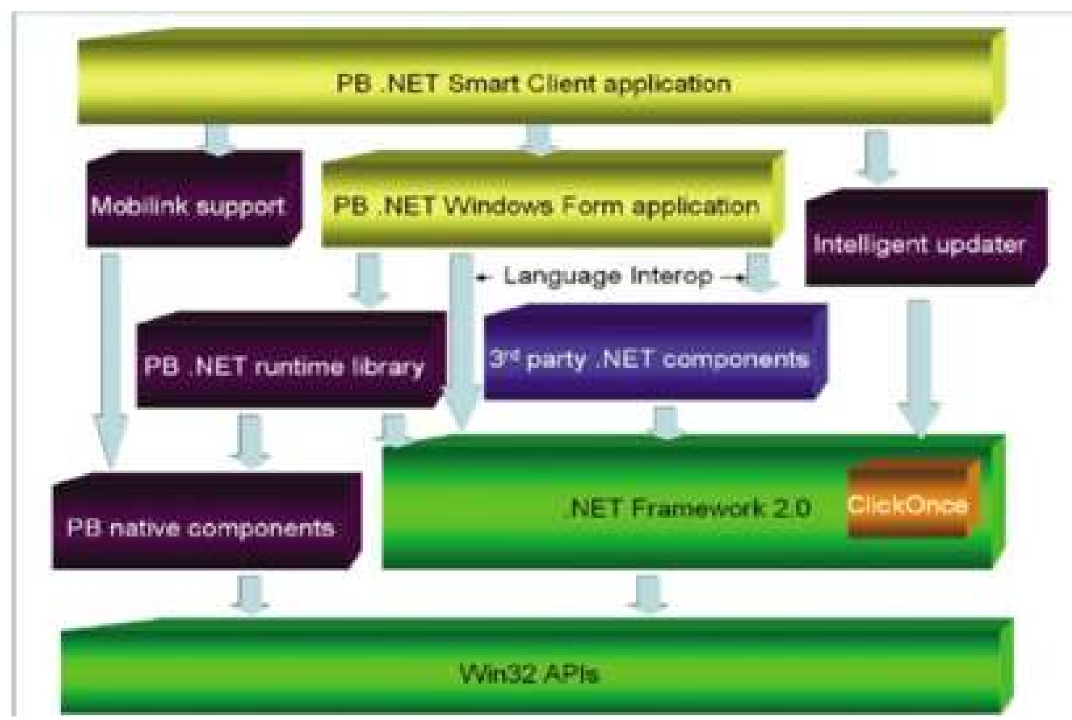
Example architectures

- 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
  - Example: Java compiler, 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 multiple 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)
- 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
- A large time sink in even medium-sized projects
  - Worth it!

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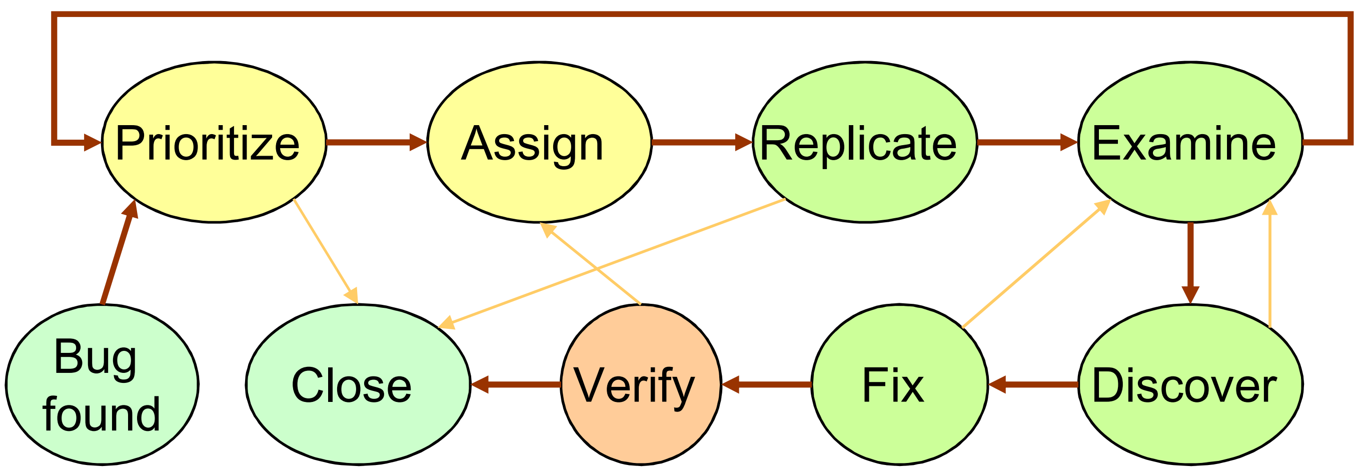
Bug tracking

- 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)

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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Scheduling

- "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?
- Facts
  1. Estimates are almost always too optimistic
  2. Estimates reflect what one wishes to be true
  3. We confuse effort with progress
  4. Progress is poorly monitored
  5. 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
  - Major milestones should change many policies around
  - Check-in rules, build process etc.

- Some typical milestones
  - Design complete
  - Interfaces complete / feature complete
  - Code complete / code freeze
  - Alpha release
  - Beta release
  - 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 – there is a startup cost (“mythical man-month”)
  - Buy components – hard in mid-stream
  - Change deliverables
  - Change schedule
- Take no small slips
  - One big adjustment is far better than three small ones

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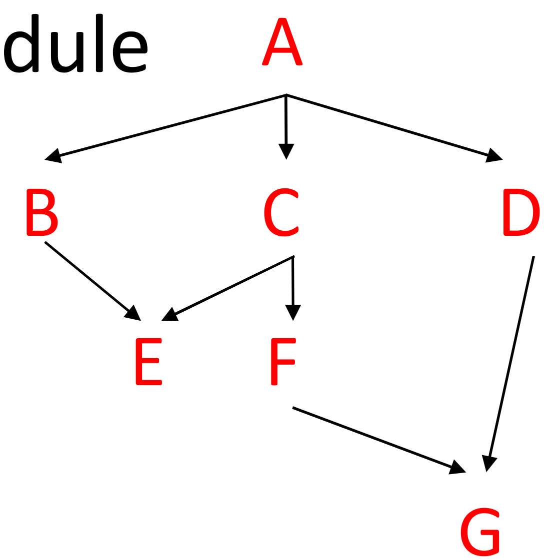
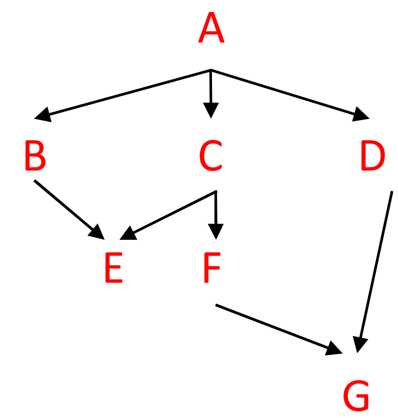
How to code and test your design

- 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



- Before implementing/testing any module
  - implement/test its children
  - For example: G, E, B, F, C, D, A
- G is tested stand-alone (so is 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

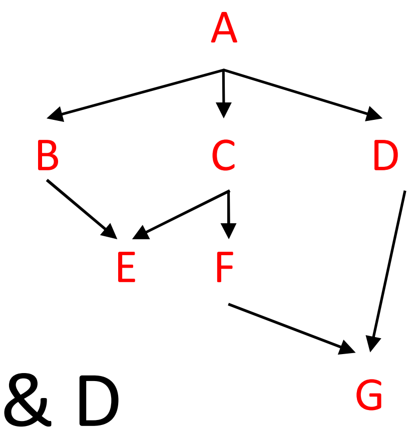
Test harnesses

- 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

- When a change is made
  - Make sure that things that used to work still do
  - Including performance
- 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



- Before implement/test a module, implement/test all its clients
  - 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

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 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
  - Morale of customers and programmers improved
    - Needn’t explain how much invisible work done
    - Better understanding of where the project is
    - Don’t have integration hanging over your head