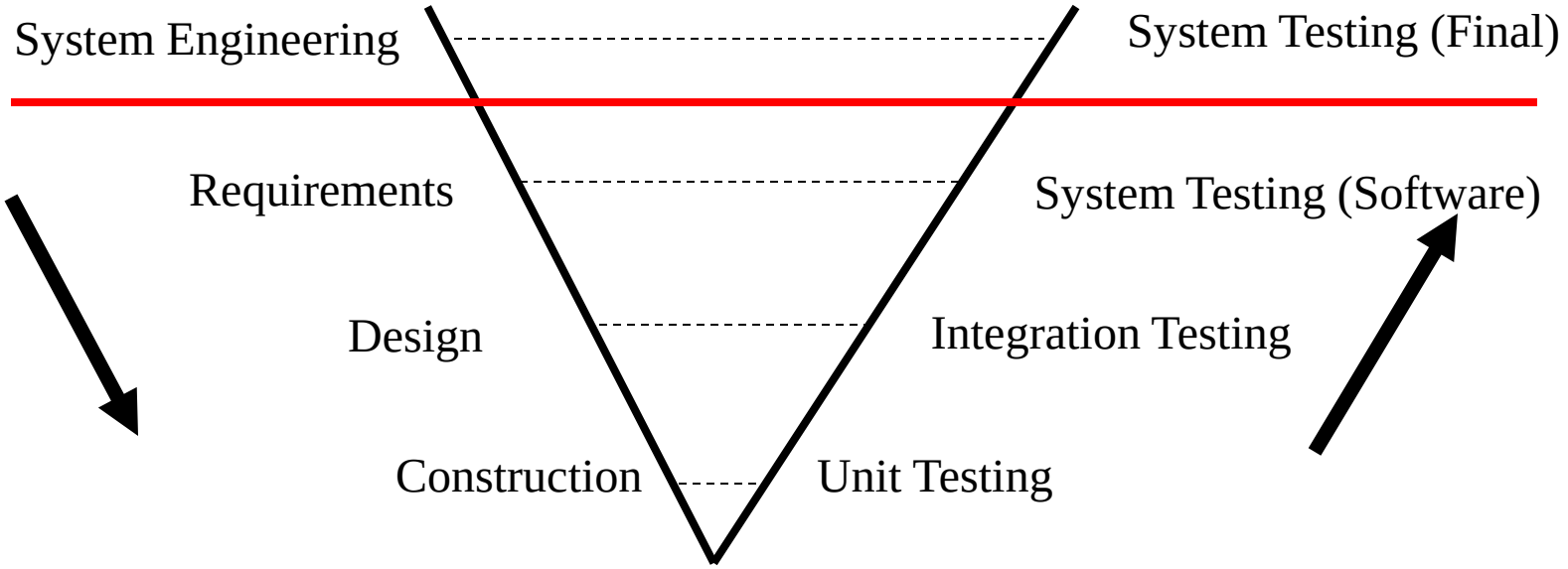
Testing Strategies

Sources:
Code Complete, 2nd Ed., Steve McConnell
Software Engineering, 5th Ed., Roger Pressman
Testing Computer Software, 2nd Ed., Cem Kaner, et. Al.

Overall Testing Strategy



- System Engineering
  - The software you're building may be only one part of a much larger system containing many hardware and software components
  - System Engineering deals with engineering the entire system, not just the software components, and goes beyond the scope of Software Engineering

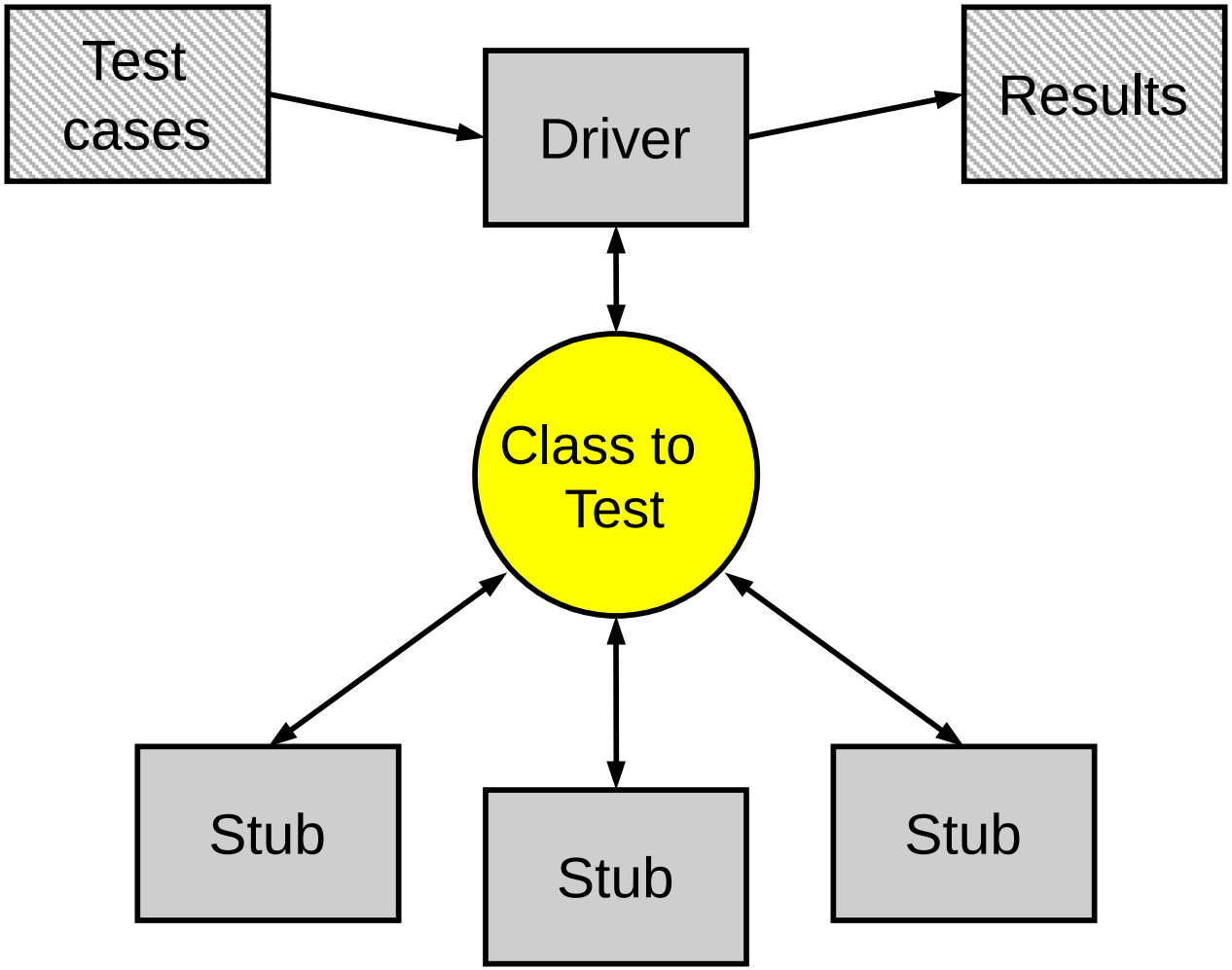
Unit Testing

- Testing of individual software "units" (i.e., classes, routines)
- White box testing
- Usually done by the engineer who wrote the unit

Unit Testing: Test-Driven Development

- The traditional approach is to write unit test cases after the code is written
- Test-Driven Development is a relatively new approach that encourages writing unit test cases before the code is written
  - Writing test cases first forces you to think about the requirements and design before writing the code, which leads to a better design
  - Since your test cases will fail at first, they help you know when the code is done (i.e., when the tests work, you're done)
  - Writing test cases before the code doesn't take any more effort than writing them after the code
  - Writing test cases first will help you detect and remove bugs sooner

Unit Testing: Using stubs and drivers to isolate the class under unit test



Unit Testing: What do stubs do?

- Do nothing
- Validate the method inputs
- Validate method call sequence (including parameter values)
- Send a message to a log
- Return a hard-coded answer regardless of the input
- Select an answer from a pool of hard-coded answers
  - Cycle through the pool or randomly select one
- Randomly generate an answer
- Prompt the user for the answer
- Simple implementation of the module that is slower, less accurate, or somehow less capable than the real module
- Pause for awhile to simulate the time taken by the real module
- Generate errors (e.g., throw exceptions) that are hard to produce for real

Unit Testing: What do drivers do?

- Invokes the class with fixed inputs
  - If an oracle is available, inputs can be generated rather than fixed
- Compares actual outputs with expected outputs
- Records failure if expected and actual outputs don’t match
- Normally continues to execute even if a test case fails
- Generates report detailing what worked and what didn’t

- Drivers and stubs must be designed together
- Since stubs don’t produce “real” outputs, the expected results in the driver must take into account the “fake” behavior of the stubs

Integration Testing

- Integration involves combining the individual software units into larger functional units

- If the units work individually, why wouldn't they work when you put them together?
  - Ask the 2010 Miami Heat

- Example: Interactions between units may be flawed
  - Mars Orbiter disaster caused by one module assuming English units and another assuming Metric units

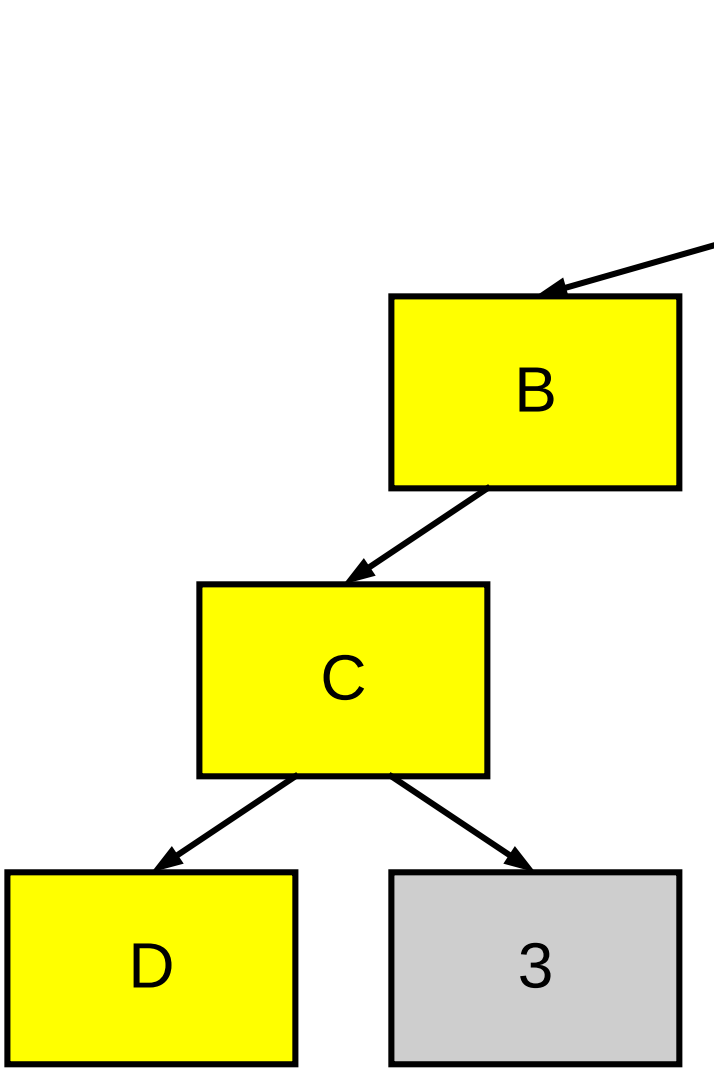
Integration Testing

- Big-Bang integration
  - Entire system is integrated at once
  - The system doesn't work, and you don't know why

- Incremental integration
  - Add a piece, retest the system, Add a piece, retest the system, …
  - If it breaks, you know what caused the problem (i.e., the last piece you added)

- Integration Testing is testing that's done during integration to ensure that the system continues to work each time a new piece is added

Top-Down Integration Testing

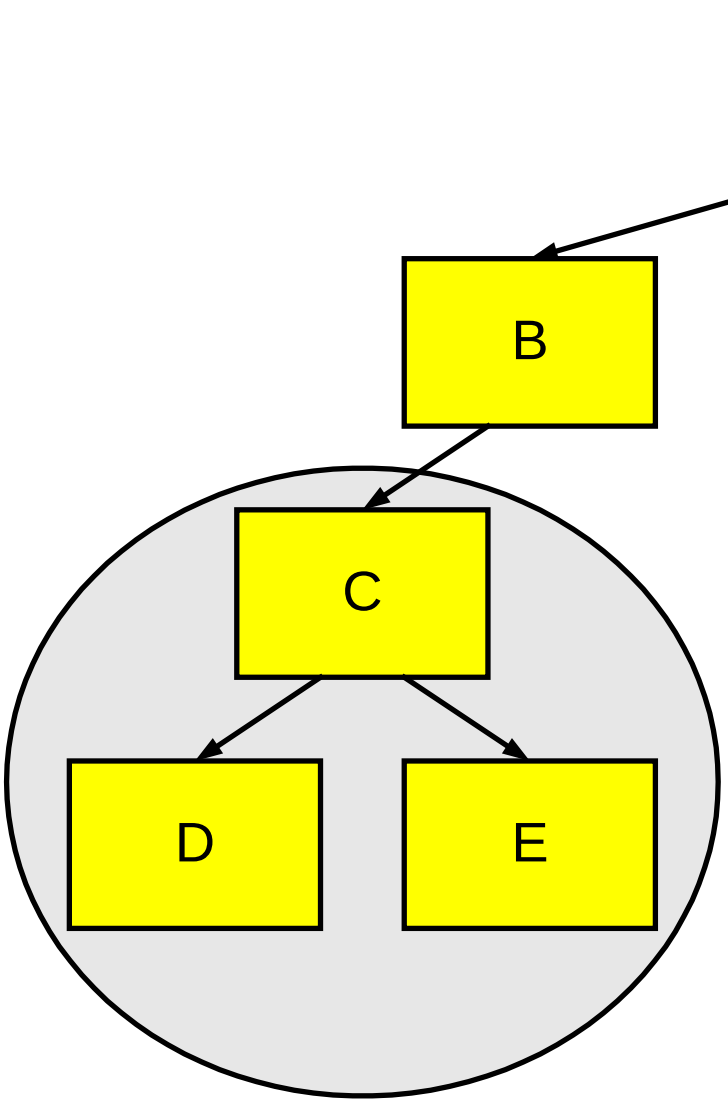


Top module is tested with stubs

Stubs are replaced one at a time, either breadth-first or depth-first

Tests are run each time new modules are integrated

Bottom-Up Integration Testing



Modules are integrated in a bottom-up fashion until the entire system has been assembled

Tests are run each time new modules are integrated

Drivers must be developed, but stubs are not needed

Sandwich Integration

- Combination of top-down and bottom-up integration
- Integrate from the top and from the bottom as it makes sense, and meet somewhere in the middle

Continuous Integration

- Some projects wait several weeks between integrations
- Between integrations, engineers work on their pieces in relative isolation
- Each integration produces a new "build"
- The system may not build successfully between integrations

- A better approach for many projects is "continuous integration"
- A minimal working system is checked into source control
- Engineers check in new code every time they finish a meaningful unit of work
- Engineers must never break the build, and are responsible for adding new test cases to exercise the new code
- The system is built and tests are run every night to ensure that all is well
- The system is always integrated and build-able

Unit Testing or Integration Testing?

- Sometimes people who claim to be doing unit testing are actually doing bottom-up integration testing

- How do you tell the difference?
  - Unit testing uses stubs to isolate the module under test from its dependencies
  - Bottom-up integration testing does not (i.e., modules call their “real” dependencies)

System Testing

- Black box testing to ensure that the product meets all of the specified requirements
- Performed by independent testing group
  - The testing organization should be separate from the development organization to avoid conflict of interest
  - The testing organization creates a “test plan” that details how the product will be tested
- Development delivers periodic builds of the complete system
- Acceptance test is run on new builds to verify that they're stable enough to test
  - If a build fails the acceptance test, it's rejected and no testing resources are expended on it
  - If a build passes the acceptance test, tests are run and bugs are entered into the bug tracking system

System Testing

- Before shipping a product it's important to get feedback from real customers

- Alpha Testing
  - Product not yet feature-complete (some things are missing)
  - Give the product to trusted, enthusiastic customers for evaluation
  - Could be done at your place or theirs
  - Lots of hand-holding by the developers
  - Incentives to alpha testers could include influence on product features or early access to needed features

- Beta Testing
  - Product much closer to shipment than with alpha testing
  - Product is feature-complete (debugging and tuning still in progress)
  - Broader distribution to a less selective group of customers
  - Less hand-holding
  - Incentives could include cash, free software or customer support, early access to needed features

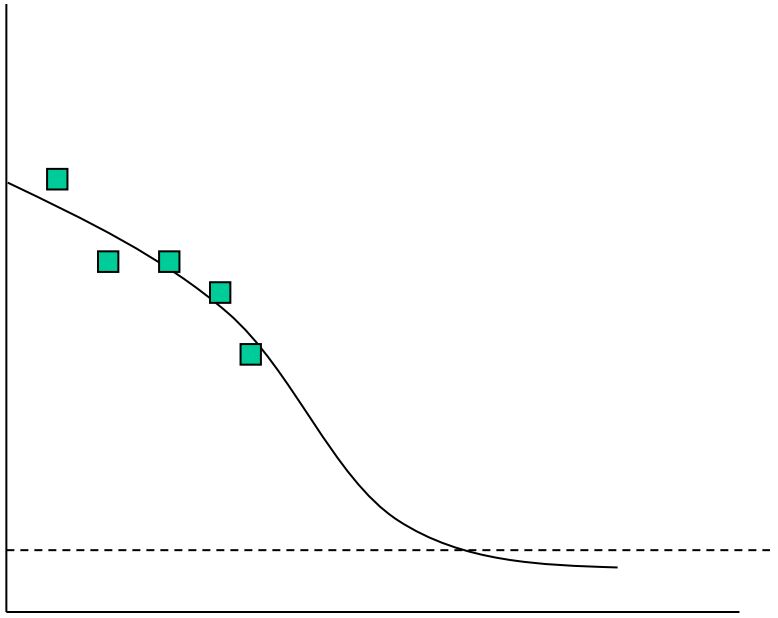
System Testing

- When are we done testing?
- "You're never done testing, the burden simply shifts from you to your customer."
- "You're done testing when you run out of time or you run out of money."
- You're done testing when:
  - All "show stopper" bugs have been fixed
  - The rate at which new bugs are being found falls below some acceptable threshold
    - If your testing is thorough, the rate at which you're finding new bugs is correlated to how many bugs still remain

System Testing

- Can we predict when we'll be done testing in advance?
  - An estimation and scheduling problem

- How about this?
  - Record the rate at which you're finding bugs each week
  - Once you've got several data points, fit a curve to the data that can be used to predict the date at which the bug rate will be low enough to ship
  - This might be better than guessing



Regression Testing (I)

- Any change to a software product, even a slight one, has the potential to cause bugs anywhere in the system
- Basically, you have to assume that anything can break at any time
- Regression testing is done on every build to ensure that new code (including bug fixes) did not break features that used to work
- It's not feasible to re-run all prior tests on every build (especially manual tests)
- The regression test suite is a subset of tests that covers all product areas and can feasibly be run on every build
- The regression test suite will evolve (i.e., grow larger) over time

Regression Testing (II)

- In addition to having regression tests that cover all functional areas of the product, you should also have a regression test for every bug that has been fixed
- Whenever a bug is discovered, if you don't already have one, design a test case that can be used later to verify that the bug has been fixed
- After the bug is fixed, re-run the test case on each new build to ensure that the bug stays fixed
- Experience has shown that fixed bugs often get “unfixed” later
- Why?
  - Source control mistakes (i.e., somebody unintentionally overwrites the bug fix in the code repository)
  - The bug fix was “fragile” (i.e., it barely worked, and some later change pushes it over the edge)
  - The feature in which the bug was found is later redesigned and re-implemented. The original mistake is repeated, thus reintroducing the bug

Customer Acceptance Testing

- After system testing is complete, the customer might perform a "customer acceptance test" before signing off on the product

- The customer acceptance test is a suite of tests that will be run by the customer (or someone they hire) to ensure that the product meets requirements