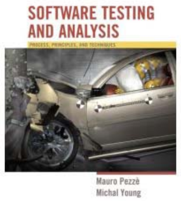
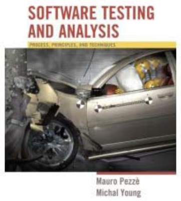
Test Execution



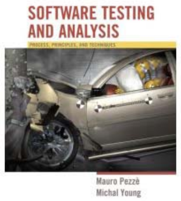
Learning objectives

- Appreciate the purpose of test automation
  - Factoring repetitive, mechanical tasks from creative, human design tasks in testing
- Recognize main kinds and components of test scaffolding
- Understand some key dimensions in test automation design
  - Design for testability: Controllability and observability
  - Degrees of generality in drivers and stubs
  - Comparison-based oracles and self-checks



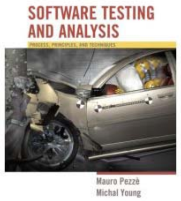
Automating Test Execution

- Designing test cases and test suites is creative
  - Like any design activity: A demanding intellectual activity, requiring human judgment
- Executing test cases should be automatic
  - Design once, execute many times
- Test automation separates the creative human process from the mechanical process of test execution



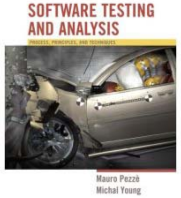
Generation: From Test Case Specifications to Test Cases

- Test design often yields test case specifications, rather than concrete data
  - Ex: “a large positive number”, not 420023
  - Ex: “a sorted sequence, length > 2”, not “Alpha, Beta, Chi, Omega”
- Other details for execution may be omitted
- Generation creates concrete, executable test cases from test case specifications



Example Tool Chain for Test Case Generation & Execution

- We could combine …
  - A combinatorial test case generation (like genpairs.py) to create test data
    - Optional: Constraint-based data generator to “concretize” individual values, e.g., from “positive integer” to 42
  - DDSteps to convert from spreadsheet data to JUnit test cases
  - JUnit to execute concrete test cases
- Many other tool chains are possible …
  - depending on application domain



SOFTWARE TESTING AND ANALYSIS

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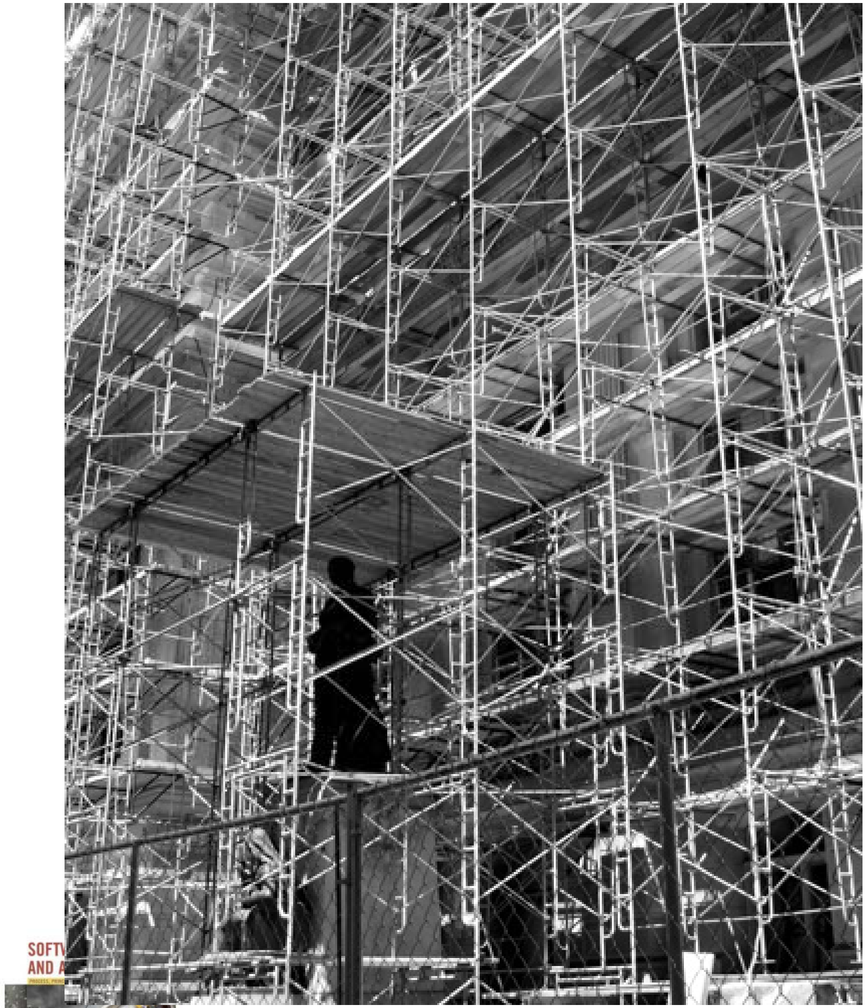
Scaffolding



- Code produced to support development activities (especially testing)
  - Not part of the "product" as seen by the end user
  - May be temporary (like scaffolding in construction of buildings
- Includes
  - Test harnesses, drivers, and stubs

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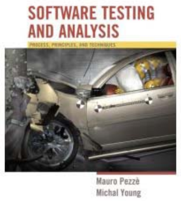
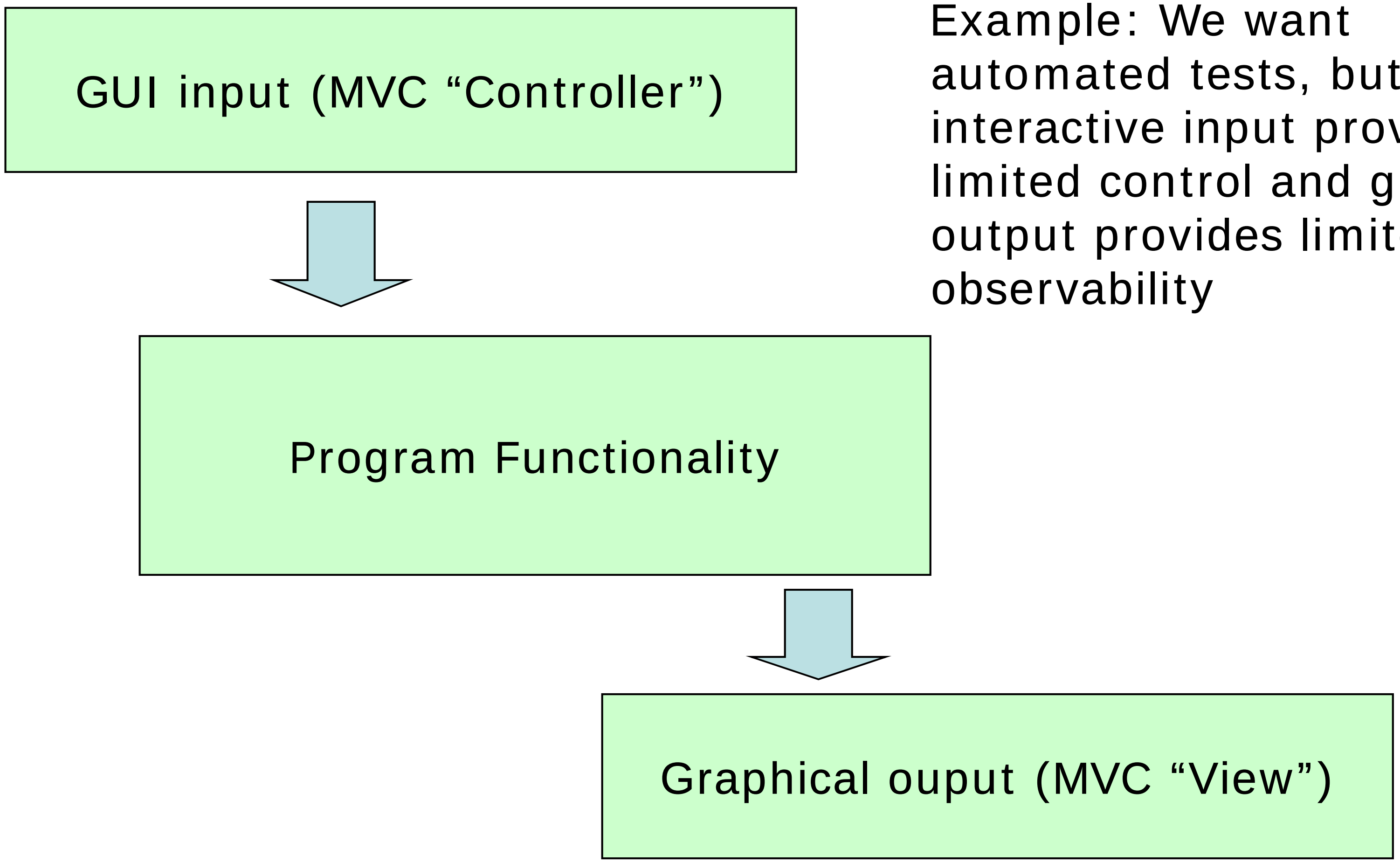
Scaffolding ...

- Test driver
  - A “main” program for running a test
    - May be produced before a “real” main program
    - Provides more control than the “real” main program
      - To driver program under test through test cases
- Test stubs
  - Substitute for called functions/methods/objects
- Test harness
  - Substitutes for other parts of the deployed environment
    - Ex: Software simulation of a hardware device

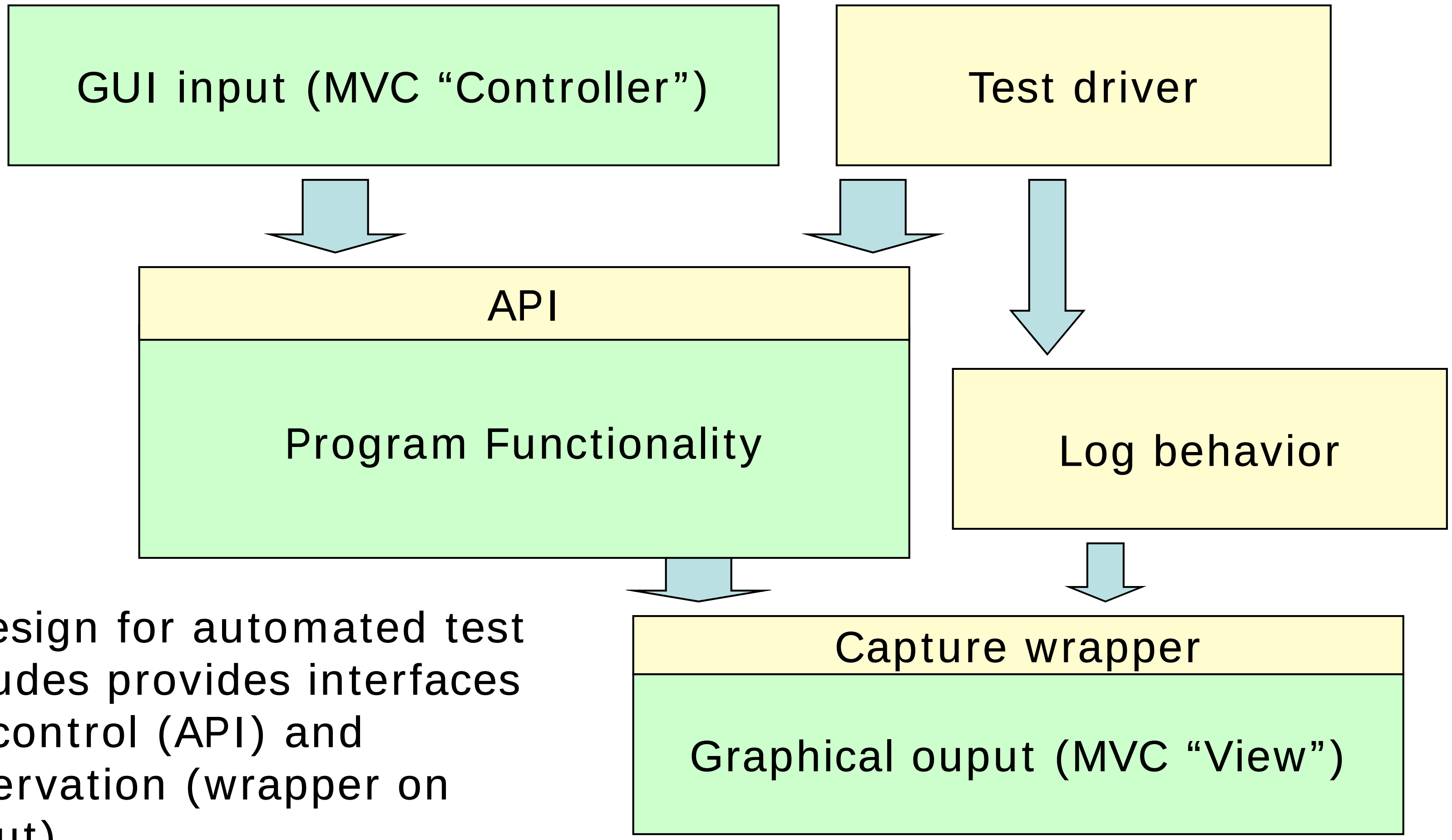


Controllability & Observability



Example: We want automated tests, but interactive input provides limited control and graphical output provides limited observability

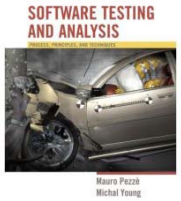
Controllability & Observability



A design for automated test includes provides interfaces for control (API) and observation (wrapper on ouput).

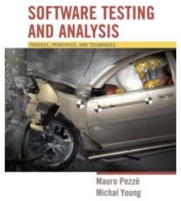
Generic or Specific?

- How general should scaffolding be?
  - We could build a driver and stubs for each test case
  - … or at least factor out some common code of the driver and test management (e.g., JUnit)
  - … or further factor out some common support code, to drive a large number of test cases from data (as in DDSteps)
  - … or further, generate the data automatically from a more abstract model (e.g., network traffic model)
- A question of costs and re-use
  - Just as for other kinds of software

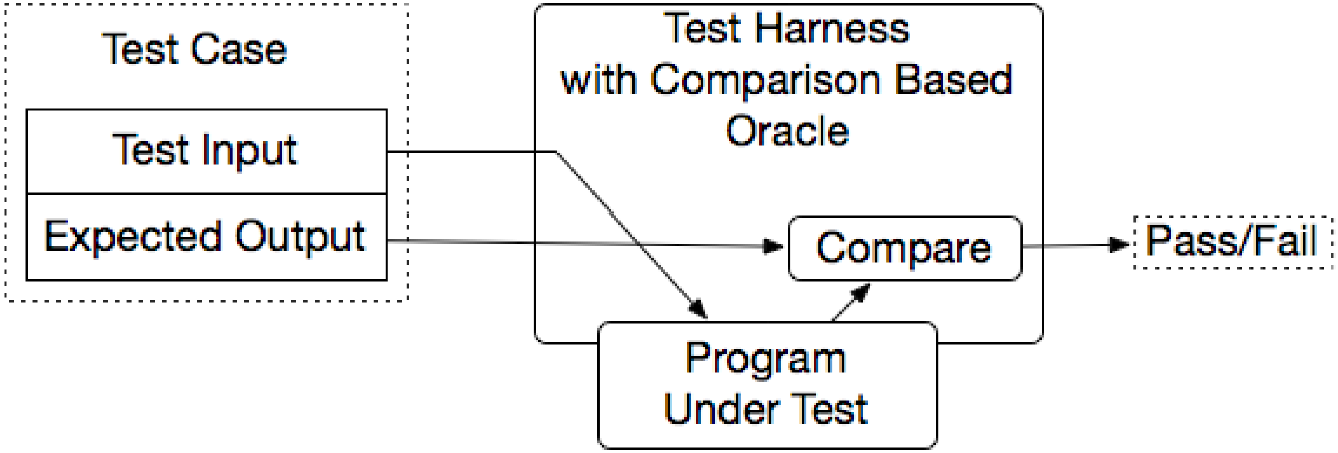


Oracles

- Did this test case succeed, or fail?
  - No use running 10,000 test cases automatically if the results must be checked by hand!
- Range of specific to general, again
  - ex. JUnit: Specific oracle (“assert”) coded by hand in each test case
  - Typical approach: “comparison-based” oracle with predicted output value
  - Not the only approach!

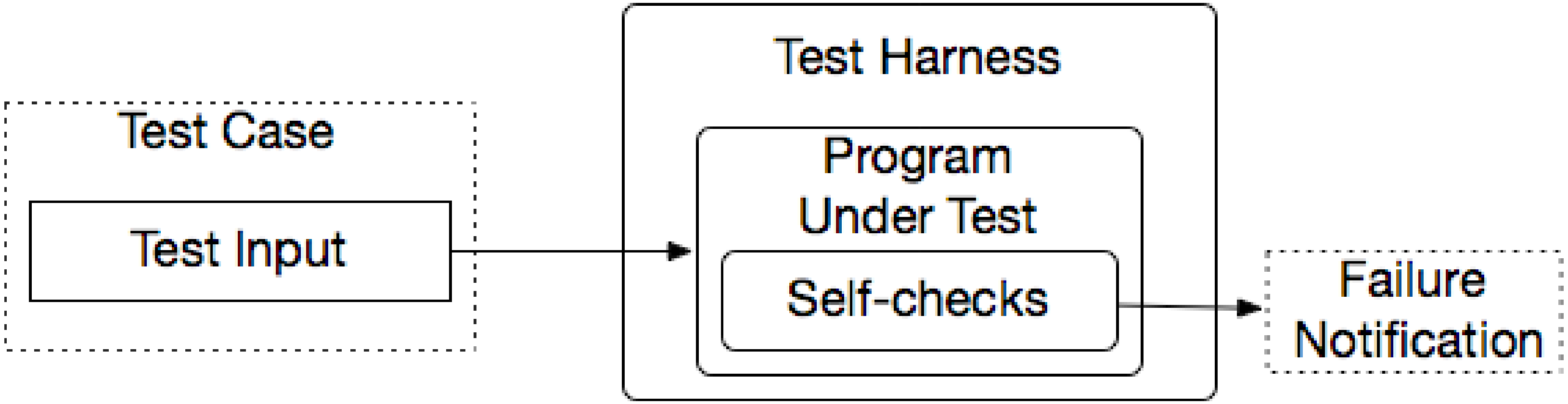


Comparison-based oracle

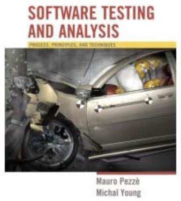


- With a comparison-based oracle, we need predicted output for each input
  - Oracle compares actual to predicted output, and reports failure if they differ
- Fine for a small number of hand-generated test cases
  - E.g., for hand-written JUnit test cases

Self-Checking Code as Oracle

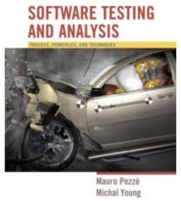


- An oracle can also be written as *self-checks*
  - Often possible to judge correctness without predicting results
- Advantages and limits: Usable with large, automatically generated test suites, but often only a *partial* check
  - e.g., structural invariants of data structures
  - recognize *many* or *most* failures, but not all



Capture and Replay

- Sometimes there is no alternative to human input and observation
  - Even if we separate testing program functionality from GUI, some testing of the GUI is required
- We can at least cut *repetition* of human testing
- *Capture* a manually run test case, *replay* it automatically
  - with a comparison-based test oracle: behavior same as previously accepted behavior
    - reusable only until a program change invalidates it
    - lifetime depends on abstraction level of input and output



Summary

- Goal: Separate creative task of test design from mechanical task of test execution
  - Enable generation and execution of large test suites
  - Re-execute test suites frequently (e.g., nightly or after each program change)
- Scaffolding: Code to support development and testing
  - Test drivers, stubs, harness, including oracles
  - Ranging from individual, hand-written test case drivers to automatic generation and testing of large test suites
  - Capture/replay where human interaction is required