Model-Driven Test Design

CS 3250 Software Testing

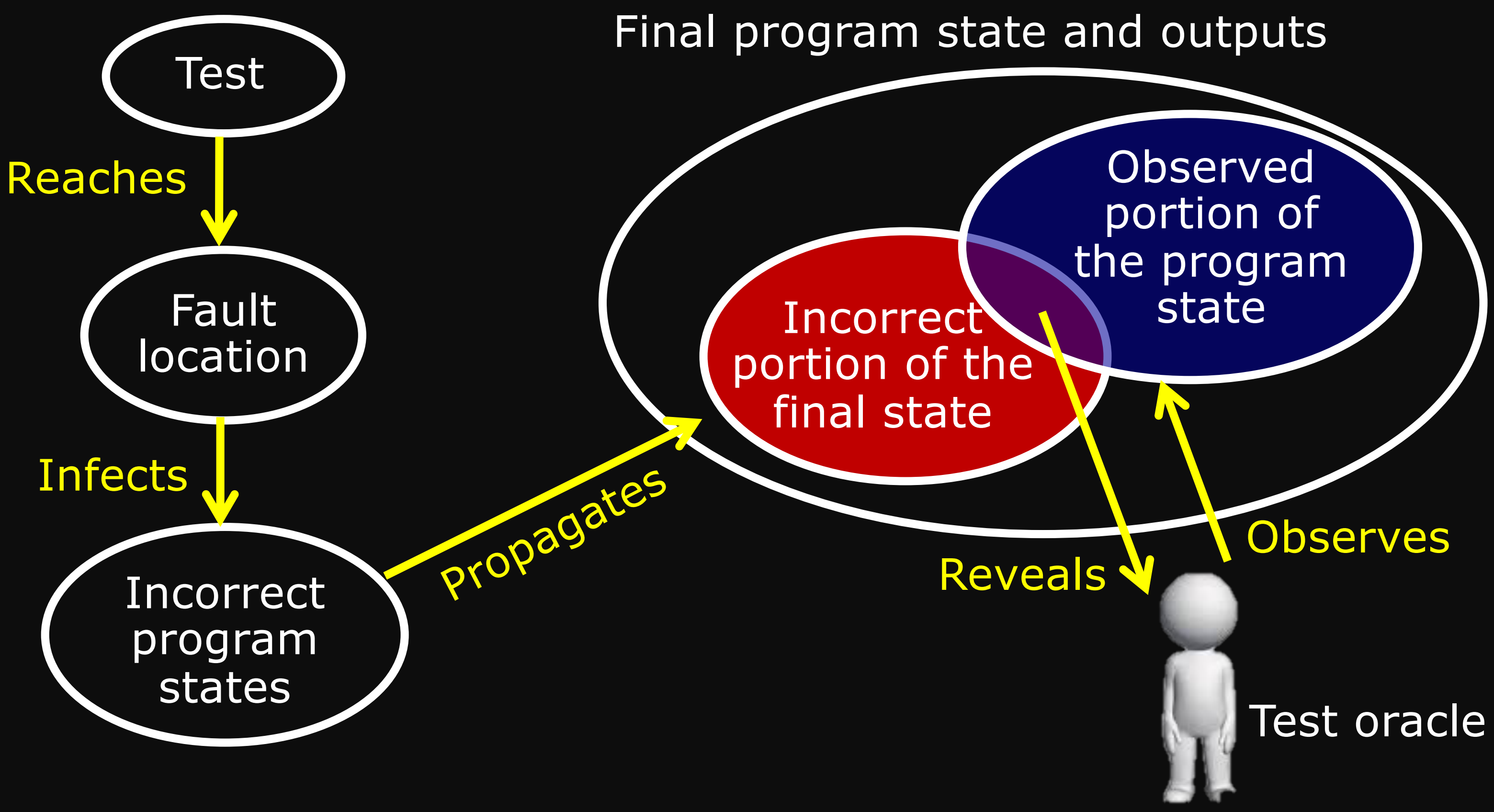
"Designers are more efficient and effective if they can raise their level of abstraction." – Jeff Offutt

[Ammann and Offutt, "Introduction to Software Testing," Ch. 2]

Revisit

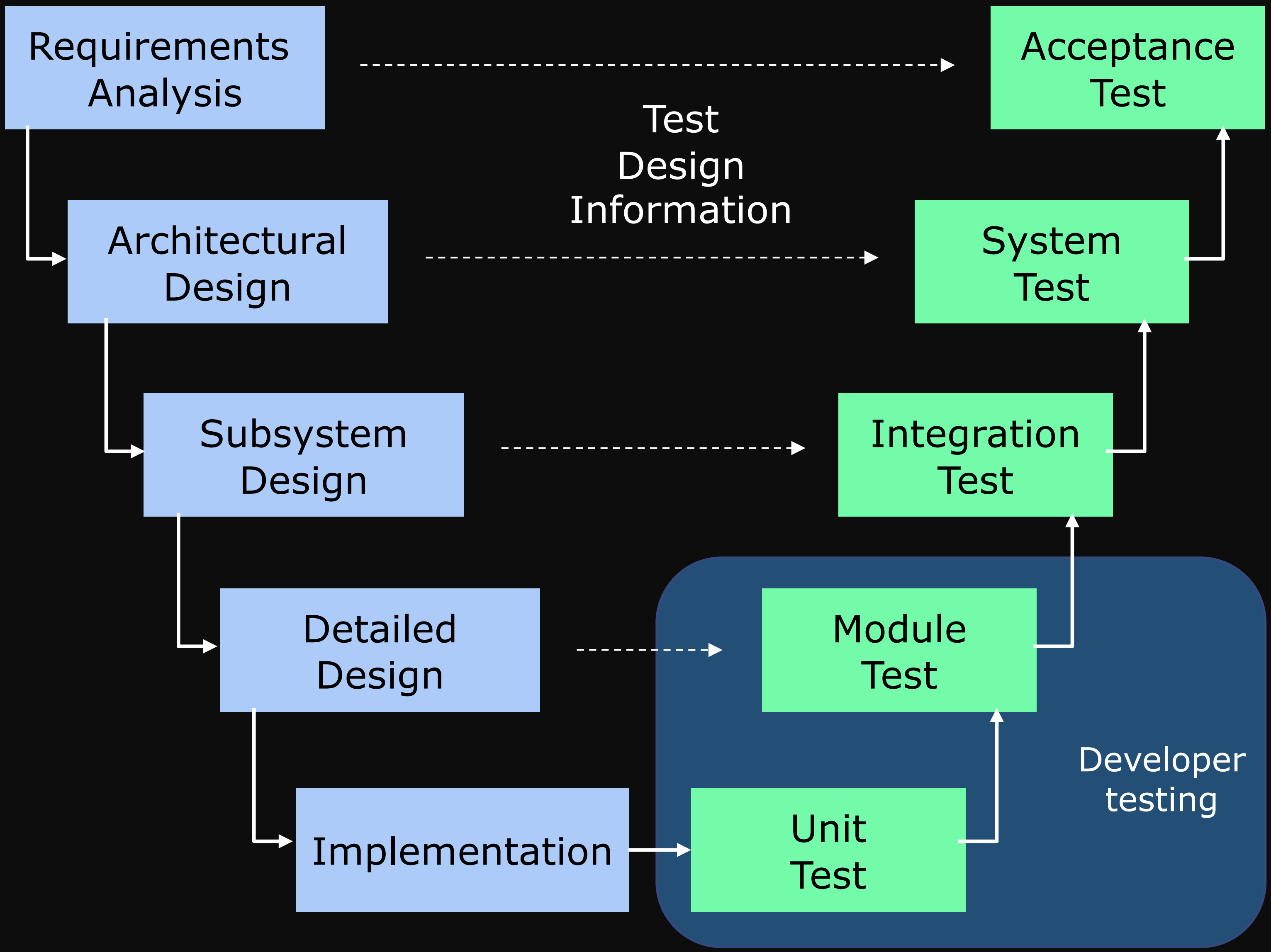
RIPR Model

- Testing can only show the presence of failures, not the absence
- Sometimes refer to as Fault, Error, Failure model
- Not all inputs will "trigger" a fault into causing a failure
- RIPR: Four conditions necessary for a failure to be observed


Test
Reaches
Fault location
Infects
Incorrect program states
Propagates
Final program state and outputs
Incorrect portion of the final state
Observed portion of the program state
Reveals
Observes
Test oracle

[AO, p.21]

Testing Levels and Types of Faults



Check if software does what the user needs

Check overall behavior w.r.t. the specs

Check interface between modules in the same subsystem

Check interactions of units and associated data structures

Check each unit (method) individually

[based in part on AO, p.23]

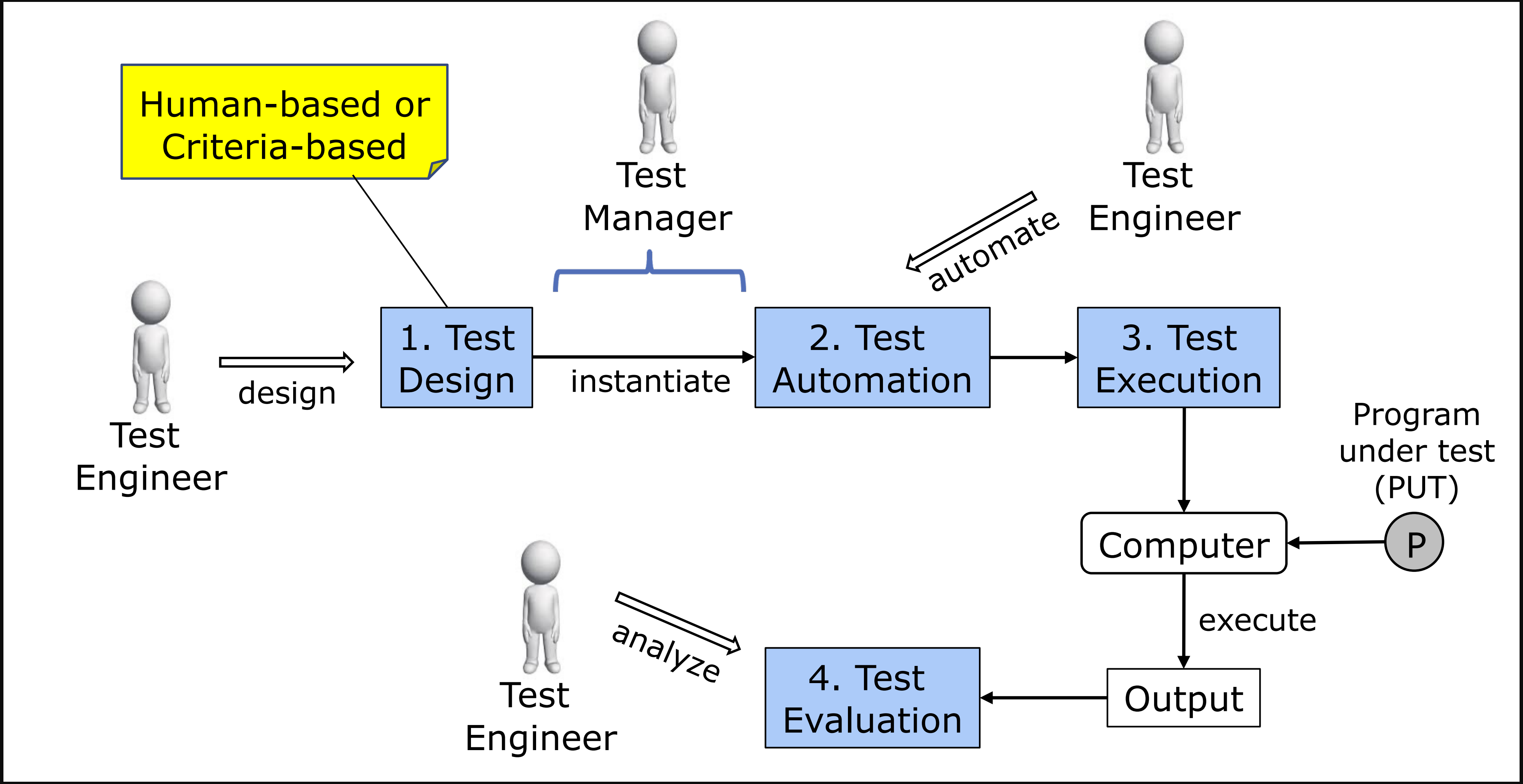
Old View: Colored Boxes

- Black-box testing
  - Derive tests from external descriptions of the software, including specifications, requirements, and design
- White-box testing
  - Derive tests from the source code internals of the software, including branches, conditions, and statements
- Model-based testing (MBT)
  - Derive tests from a model of the software (such as a UML diagram)
- Model-Driven Test Design (MDTD)
  - Focus on "from what abstraction level do we derive tests?"

Model-Driven Test Design (MDTD)

- Break testing into a series of small tasks that simplify test generation
- Isolate each task
- Work at a higher level of abstraction
  - Use mathematical structures to design test values independently of the details of software or design artifacts, test automation, and test execution
- Key intellectual step: test case design
- Test case design -- the primary factor determining whether tests successfully find failures in software

Software Testing Activities



Each activity requires different skills, background knowledge, education, and training.

[AO, p.22]

1. Test Design

Human-based approach

- Design test values based on
  - Domain knowledge of the program
  - Human knowledge of testing
  - Knowledge of user interface
- Require almost no traditional CS degree
  - Essential – background in the software domain
  - Helpful – empirical background (biology, psychology, …)
  - Helpful – logic background (law, philosophy, math, …)

Criteria-based approach

- Design test values to satisfy coverage criteria
- The most technical job in software testing
- Require knowledge of
  - Discrete math
  - Programming
  - Testing
- Require a traditional CS degree
- Using people who are not qualified to design tests will result in ineffective tests

Coverage Criteria

- Testers search a huge input space -- to find the fewest inputs that will reveal the most problems

How to search, when to stop

- Coverage criteria give structured, practical ways to search the input space

- Advantages of coverage criteria
  - Search the input space thoroughly
  - Not much overlap in the tests
  - Maximize the "bang for the buck"
  - Provide traceability from software artifacts to tests
  - Make regression testing easier
  - Provide a "stopping rule"
  - Can be well supported with tools

Test Criteria and Requirements

- Test criterion: A collection of rules and a process that define test requirements

  Examples: Cover every statement
  Cover every functional requirement

- Test requirements: Specific things that must be satisfied or covered during testing

  Examples: Each statement
  Each functional requirement

Many criteria have been defined. They can be categorized into four types of structures.

1. Input domains
2. Graphs
3. Logic expressions
4. Syntax descriptions

Characteristics of Good Tests

Each test case:

- Test one thing
  - Have accurate purpose
  - Traceable to requirement or design
- Clear and easy to understand
- Relatively small
- Independent
- Precise and concise
- Repeatable

2. Test Automation

- Embed test values into executable scripts
- Slightly less technical
- Require knowledge of programming
- Require very little theory
- Often involve observability and controllability issues
- Can be boring for test designers
- Programming is out of reach for many domain experts
- Who should determine and embed the expected outputs?
    - Test designers may not always know the expected outputs
    - Test evaluators need to get involved early to help with this

3. Test Execution

- Run tests on the software and record the results
- Easy and trivial if the tests are well automated
- Requires basic computer skills
  - Interns
  - Employees with no technical background
- Can be boring for test designers
  - Asking qualified test designers to execute tests is a sure way to convince them to look for a development job
- Test executors have to be very careful and meticulous with bookkeeping

4. Test Evaluation

- Evaluate results of testing, report to developers
- This is much harder than it may seem
- Requires knowledge of
  - Domain
  - Testing
  - User interfaces and psychology
- Usually requires almost no traditional CS
  - Background in the software domain is essential
  - Empirical background is very helpful (biology, psychology, …)
  - Logic background is very helpful (law, philosophy, math, ...)

Other Activities

- Test management
  - Sets policy, organizes team, interfaces with development, chooses criteria, decides how much automation is needed, …
- Test maintenance
  - Save tests
  - Requires cooperation of test designers and test automators
  - Partly policy and partly technical
- Test documentation
  - All parties participate
  - Each test must document "why" – criterion and test requirement satisfied or a rationale for human-designed test
  - Ensure traceability throughout the process
  - Keep documentation in the automated tests

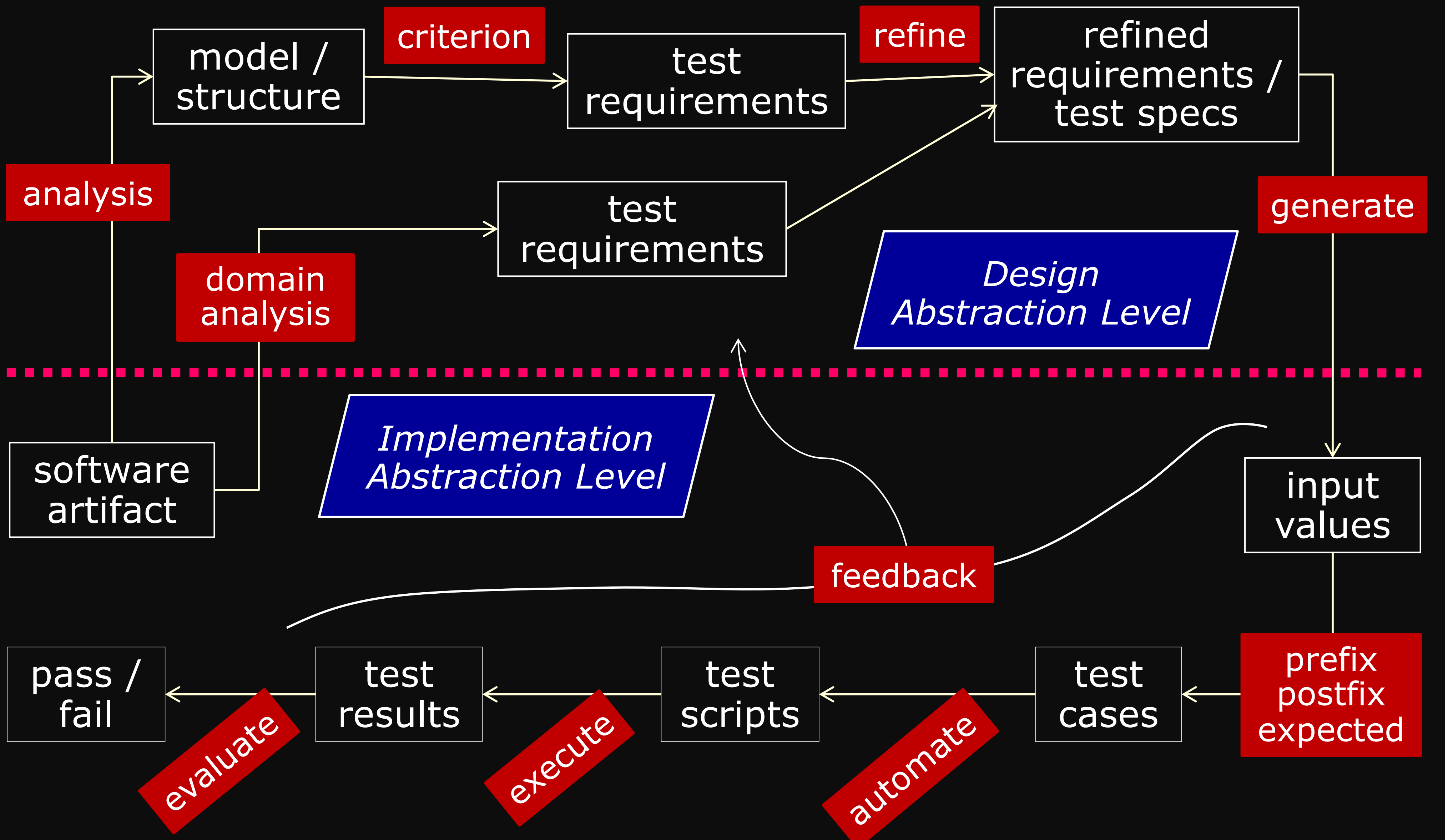
Organizing the Team

- A mature test organization needs only one test designer to work with several test automators, executors, and evaluators
- Improved automation will reduce the number of test executors
- Putting the wrong people on the wrong tasks leads to inefficiency, low job satisfaction and low job performance
  - A qualified test designer will be bored with other tasks and look for a job in development
  - A qualified test evaluator will not understand the benefits of test criteria
- Test evaluators have the domain knowledge, so they must be free to add tests that "blind" engineering processes will not think of

Using MDTD in Practice

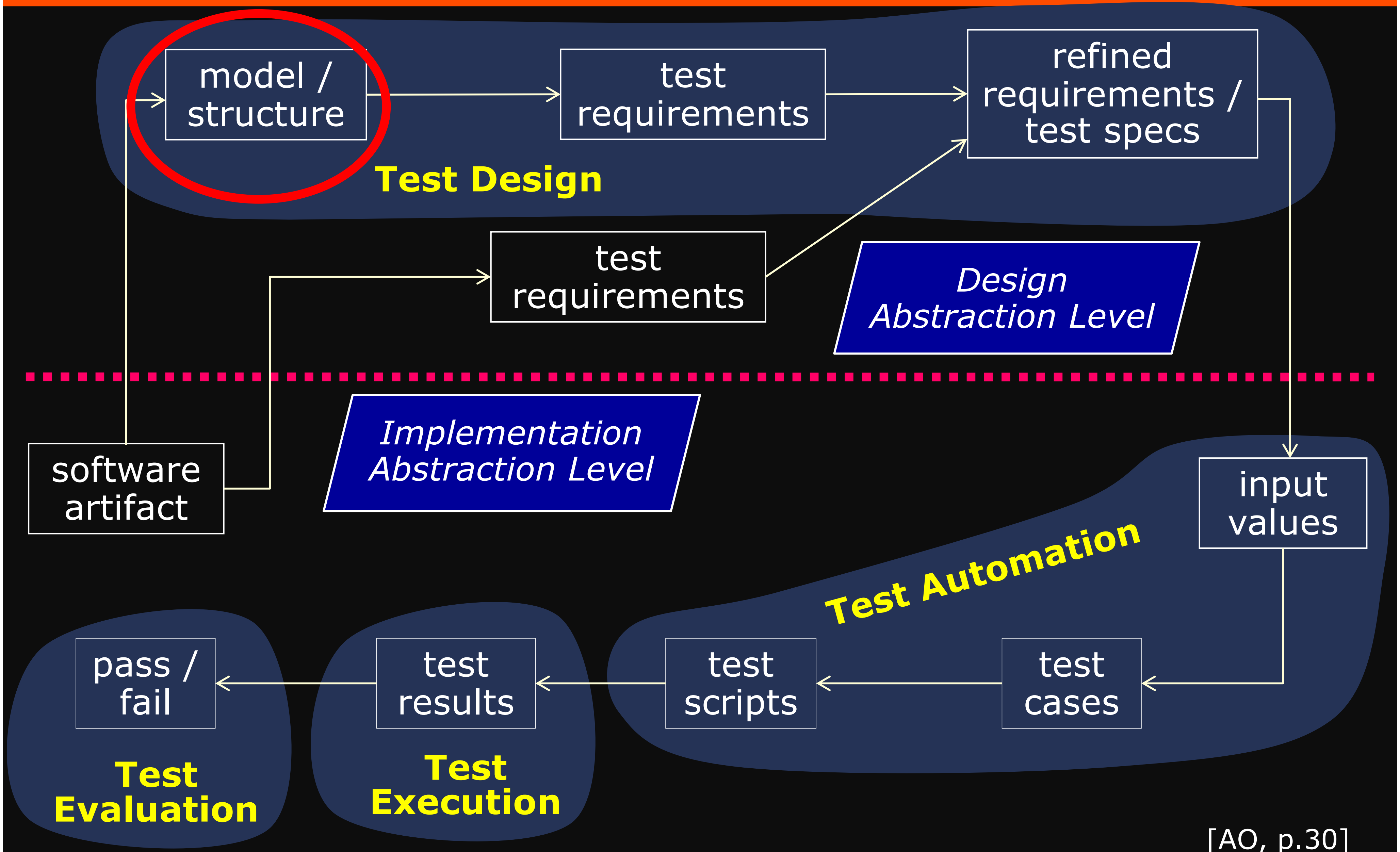
- This approach lets one test designer do the math
- Then traditional testers and programmers can do their parts
  - Find values
  - Automate the tests
  - Run the tests
  - Evaluate the tests
- Test designers become technical experts
- Many test designers get involved in crowd testing

Model-Driven Test Design - Steps



[AO, p.30]

Model-Driven Test Design - Activities



[AO, p.30]

Wrap-up

- This course focuses on test design with criteria-based approach
- Testing activities
  - Design tests: model software + apply test coverage criteria
    - Characteristics of good test cases
  - Automate tests
  - Execute tests
  - Evaluate tests

What's Next?

- Test automation