ISTQB – Foundation Level

CHAPTER 4: TEST DESIGN TECHNIQUES

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AGENDA

- 4.1 The test development process (K2)
- 4.2 Categories of test design techniques (K2)
- 4.3 Specification-based or black-box techniques (K3)
- 4.4 Structure-based or white-box techniques (K3)
- 4.5 Experience-based techniques (K2)
- 4.6 Choosing test techniques (K2)

4.1 The test development process (K2)

- Objectives
  - LO-4.1.1 Differentiate between a test design specification, test case specification and test procedure specification. (K2)
  - LO-4.1.2 Compare the terms test condition, test case and test procedure. (K2)
  - LO-4.1.3 Evaluate the quality of test cases. Do they:
    - Show clear traceability to the requirements;
    - Contain an expected result. (K2)
  - LO-4.1.4 Translate test cases into a well-structured test procedure specification at a level of detail relevant to the knowledge of the testers. (K3)

Test analysis: identifying test conditions

- Test analysis is the process of looking at something that can be used to derive test information.
  - Test basis: It could be a system requirement, a technical specification, the code itself (for structural testing), or a business process.
  - Sometimes tests can be based on an experienced user's knowledge of the system, which may
  - A test condition is simply something that we could test.
  - A testing technique helps us select a good set of tests from the total number of all possible tests for a given system.

Test design: specifying test cases

- Test design: The test cases and test data are created and specified.
- A test case consists of a set of input values, execution preconditions, expected results and execution post-conditions, developed to cover certain test condition(s).
- Expected results should be produced as part of the specification of a test case and include outputs, changes to data and states, and any other consequences of the test.
- Expected results should ideally be defined prior to test execution.

Test implementation: specifying test procedures or scripts

- Test implementation: The test cases are developed, implemented, prioritized and organized in the test procedure specification.
- The test procedure (or manual test script) specifies the sequence of action for the execution of a test.
- If tests are run using a test execution tool, the sequence of actions is specified in a test script (which is an automated test procedure).

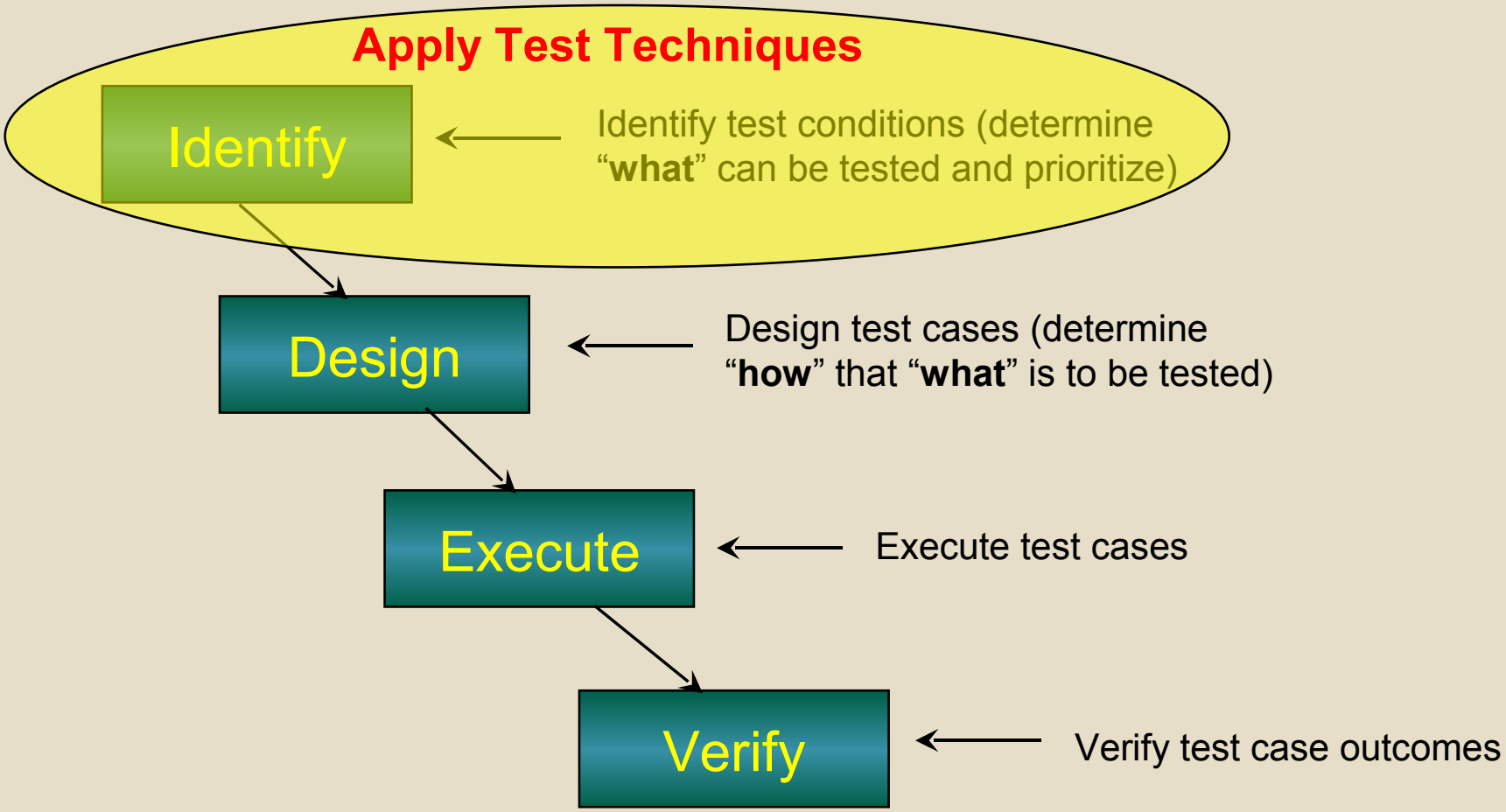
4.2 Categories of test design techniques

- Objectives
  - LO-4.2.1 Recall reasons that both specification-based (black-box) and structure-based (white box) approaches to test case design are useful, and list the common techniques for each. (K1)
  - LO-4.2.2 Explain the characteristics and differences between specification-based testing, structure-based testing and experience-based testing. (K2)

Introduction of Test Technique

- A test technique is a formalized approach to choose test conditions that give a high probability of finding defects.
- A testing technique helps us select a good set of tests from the total number of all possible tests for a given system.

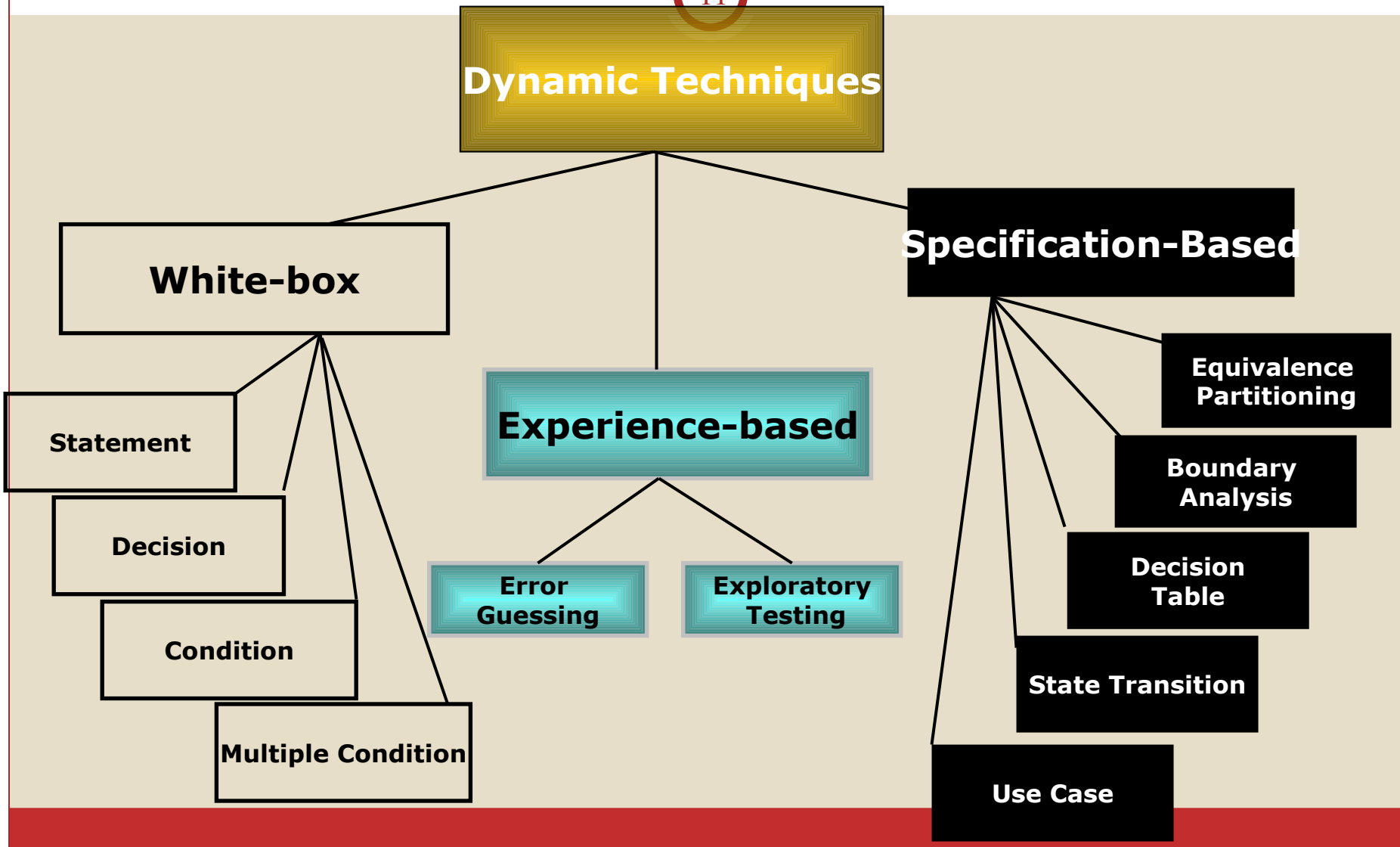
Life Cycle of Test Cases



Categories of test design techniques

- Categories of testing techniques
  - Static techniques → Chapter 3
  - Dynamic
    - Structure-based
    - Specification-based
    - Experience-based

Dynamic Testing



4.3 Specification-based or black-box techniques

- Objectives
  - LO-4.3.1 Write test cases from given software models using the following test design techniques: (K3)
    - equivalence partitioning;
    - boundary value analysis;
    - decision table testing;
    - state transition testing.
  - LO-4.3.2 Understand the main purpose of each of the four techniques, what level and type of testing could use the technique, and how coverage may be measured. (K2)
  - LO-4.3.3 Understand the concept of use case testing and its benefits. (K2)

Specification-based or black-box techniques

- Alias: Specification-based, Behavioral technique
- It is a procedure to select test cases based on software specification without reference to its internal structure.
- Black-box test techniques are appropriate at all levels of testing where a specification exists.

Specification-based or black-box techniques

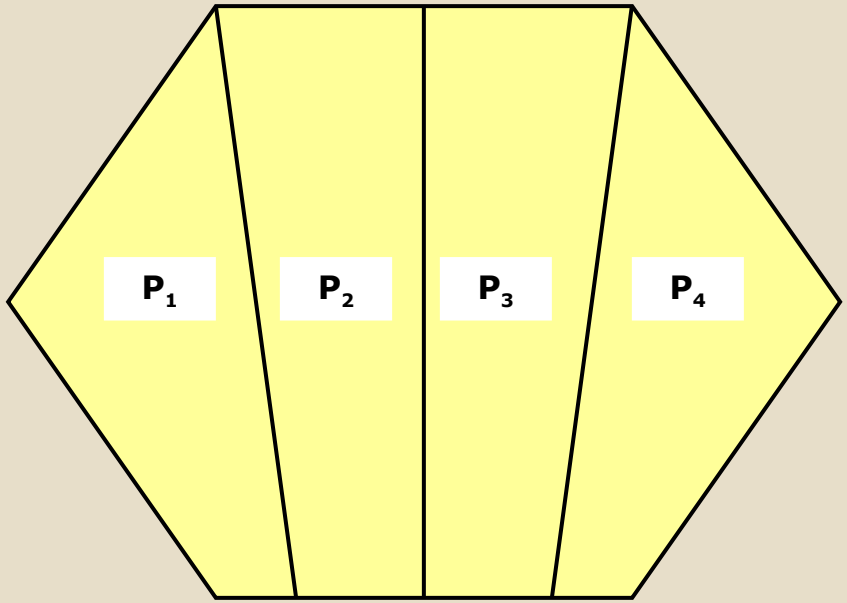
- Black-box Techniques
  - Equivalence Partitioning
  - Boundary Value Analysis
  - Decision Table
  - State Transition

Equivalence Partitioning

- Equivalence Partitioning is a test technique in which test cases are designed to execute representatives from equivalence partitions.
- Equivalence Partition:
  - Involve the same input variables
  - Exhibit similar behaviors
  - Affect the same output variables
- Test cases are designed to cover each partition at least once.

Equivalence Partitioning

- Equivalence Partitions are identified for both valid and invalid data:
  - Inputs
  - Outputs
  - Time-related values



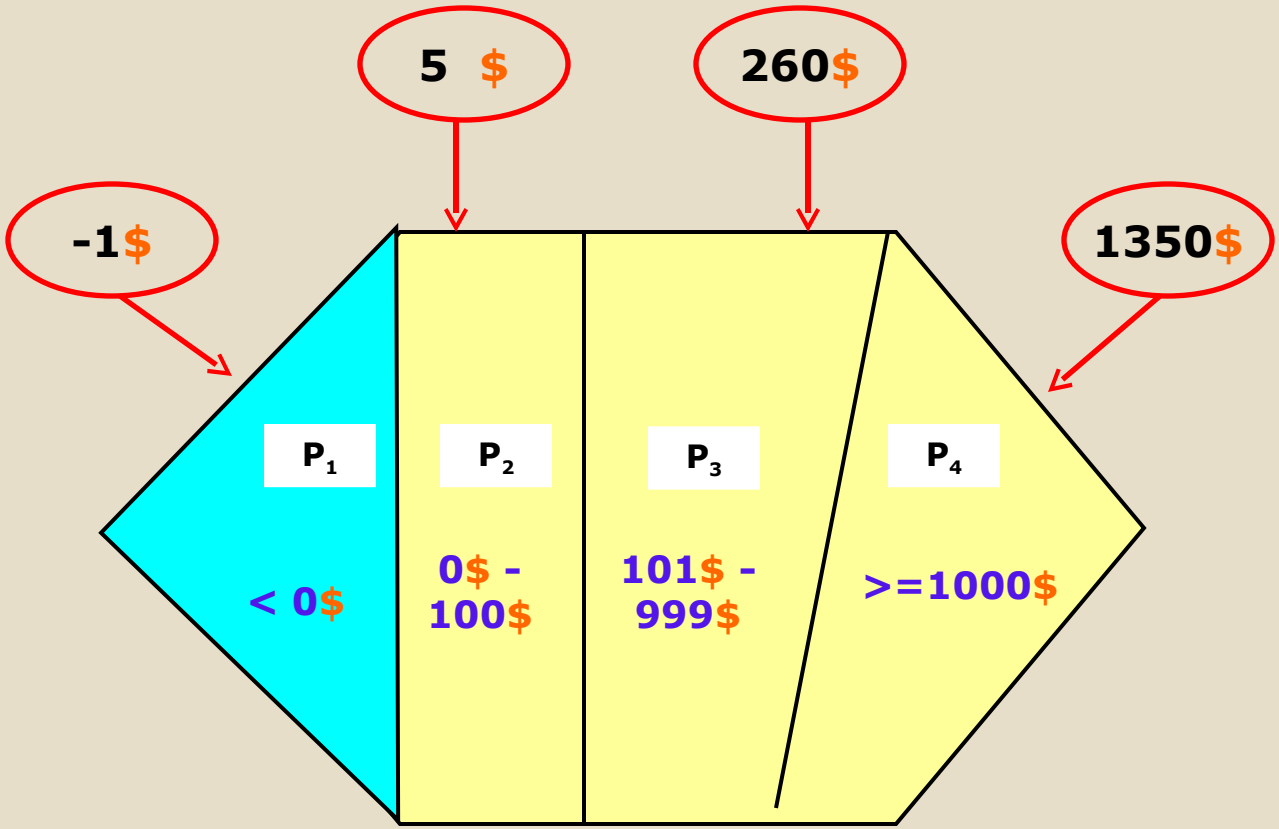
Equivalence Partitioning

- Example:
  - A saving account in a bank earns a different rate of interest depending on the balance in the account. Below are the ranges of balance values that earn the different rates of interest.

Balance Values	0$ - 100$	>100$ - <1000$	>=1000$
Interest Rate	3%	5%	7%

Equivalence Partitioning

-> We will have 4 input values for identified partitions.

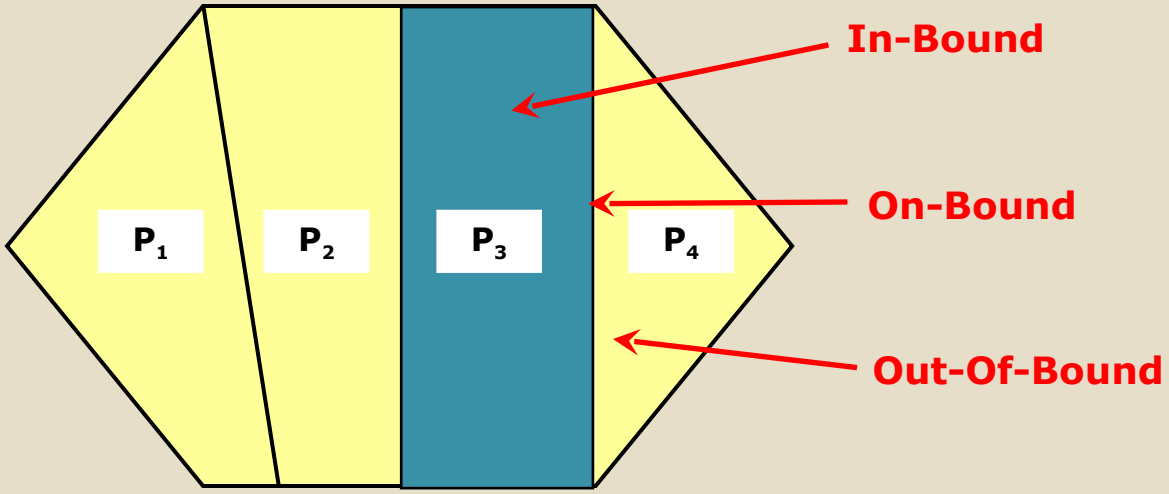


Boundary Value Analysis

- Boundary Value Analysis is a test technique in which test cases are designed based on boundary values which are the maximum and minimum values of a partition.
- The tests can be designed to cover both valid and invalid boundary values:
  - Valid partition -> Valid boundary values
  - Invalid partition -> Invalid boundary values
- Test cases are designed to cover each boundary value.

Boundary Value Analysis

- Boundaries define 3 sets of data:
  - Good (In-Bound)
  - Bad (Out-Of-Bound)
  - On-the-border (On-Bound)
- It is easy to apply and its defect finding capability is high.



Boundary Value Analysis

Example:

A printer has an input option of the number of copies to be made, from 1 to 99.

	Invalid	Valid	Invalid
Partition	<1 (page)	1 – 99 (page)	> 99 (page)
Boundary Value	0	1 99	100

->*We will have 5 boundary values:* 0, 1, 50, 99, 100.

EP & BVA Relations

- BVA is considered as an extension of EP. Boundary values are identified based on defined partitions.
- It's recommended that you test the partitions separately from boundaries.
- Depend on your test objectives, you can decide to exercise which partitions and boundaries and set their priority if need:
  - **The most thorough approach:** valid partition -> invalid partition -> valid boundaries -> invalid boundaries.
  - **Typical transactions with a minimum number of tests:** valid partition only.
  - **Find as many as defects as possible:** both valid and invalid boundaries.
  - **Ensure that the system will handle bad inputs correctly:** invalid partitions and boundaries.

Decision Table

- Decision Table is a test technique in which test cases are designed to execute the combinations of inputs and/or causes shown in a decision table.
- Decision Table:
  - Capture requirements that contain logical conditions.
  - Provide a systematic way of stating complex business rules.
  - Each column of the table corresponds to a business rule that define a unique combination of conditions.
- Test cases are designed to have at least one test per rule in the table.

Decision Table

- Each combination of conditions in decision table is referred to as a rule and have a corresponding outcome.

Conditions	Rule 1	Rule 2	Rule 3	Rule 4
Condition #1	T	T	F	F
Condition #2	T	F	T	F
Actions/Outcomes				
Outcome #1	Y		Y	

- The strength of this technique is discover omissions and ambiguities in specification.

Decision Table

- Example:
- If you are a new customer opening a credit card account, you will get a 15% discount on all your purchases today.
- If you are an existing customer and you hold a loyalty card, you get a 10% discount.
- If you have a coupon, you can get 20% off today (but it can't be used with the 'new customer' discount).
- Discount amounts are added, if applicable.

Decision Table

-> We will have 6 test cases to cover all possible rules in the decision table.

Conditions	R1	R2	R3	R4	R5	R6	R7	R8
New customer (15%)	T	T	T	T	F	F	F	F
Loyalty card (10%)	T	T	F	F	T	T	F	F
Coupon (20%)	T	F	T	F	T	F	T	F
Actions								
Discount (%)	N/A	N/A	20	15	30	10	20	0

State Transition Testing

- A system may exhibit a different response depending on current conditions or previous history
- State transition testing is much used within the embedded software industry and technical automation in general. However, the technique is also suitable for modeling a business object having specific states or testing screen-dialogue flows
- Example: software installer

State Transition Testing

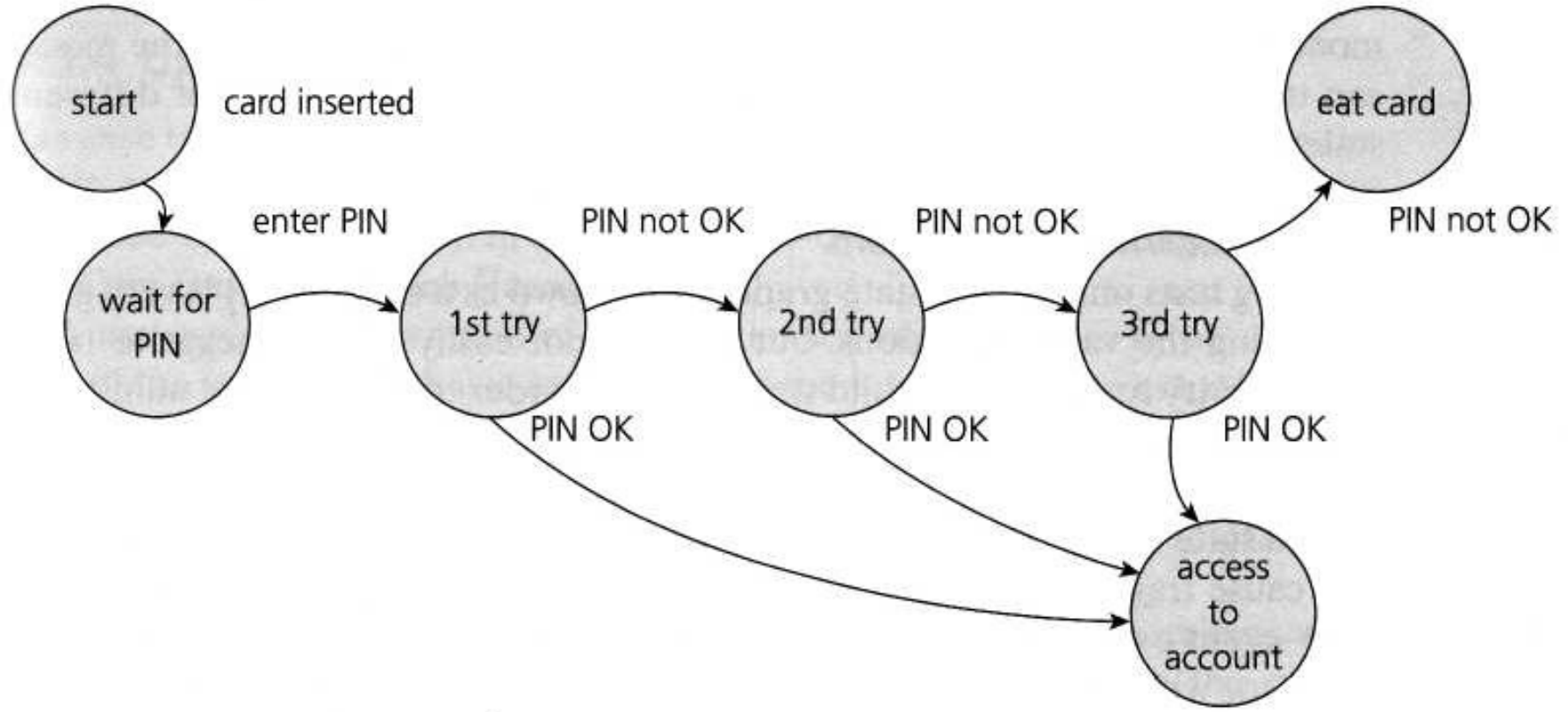


FIGURE 4.2 State diagram for PIN entry

Use Case Testing

- Use case testing is a technique that helps us identify test cases that exercise the whole system on a transaction by transaction basis from start to finish.
- Use cases describe the process flows through a system based on its most likely use.

Use Case Testing

- Example of Use Case ATM
  - The Customer withdraws cash
  - The customer checks balance
  - The customer makes deposit
  - The customer makes multiple transactions (makes deposit, checks balance, withdraws cash)

4.4 Structure-based or white-box techniques (K3)

- Objectives:
  - LO-4.4.1 Describe the concept and importance of code coverage. (K2)
  - LO-4.4.2 Explain the concepts of statement and decision coverage, and understand that these concepts can also be used at other test levels than component testing (e.g. on business procedures at system level). (K2)
  - LO-4.4.3 Write test cases from given control flows using the following test design techniques:
    - statement testing;
    - decision testing. (K3)
  - LO-4.4.4 Assess statement and decision coverage for completeness. (K3)

Statement Coverage

- Statement Coverage is the assessment of the percentage of executable statements that have been exercised by a test suite.

- Statement testing derives test cases to execute specific statements, normally to increase statement coverage.

Statement Coverage

$$\text{Statement Coverage} = \frac{\text{Number of statements exercised}}{\text{Total number of statements}} \text{ X } 100\%$$

- A statement may be on single line or spread over several lines.
- One line may contain more than one statement, just one statement or only part of a statement.

Statement Coverage

Example:

Let's look at a code sample below:

1. READ A
2. READ B
3. C = A + 2*B
4. IF C > 50 THEN
5. PRINT "Large C"
6. END

We'll have 3 tests:

- Test 1: A=2, B=3
- Test 2: A=0, B=25
- Test 3: A=47, B=1

Statement Coverage

- Statement Coverage:
  - Test 1: A=2, B=3
  - Test 2: A=0, B=25
  - Test 3: A=47, B=1

  ⇒ 85% (5/6 statements)

- Increase coverage to 100% ?

  ⇒ Test 4: A=20, B=25

Pseudo-code:

```
1. READ A
2. READ B
3. C = A + 2*B
4. IF C > 50 THEN
5.       PRINT "Large C"
6. END
```

Decision Coverage

- Decision Coverage is the assessment of the percentage of decision outcomes (e.g. the True and False options of an IF statement) that have been exercised by a test suite.

- Decision testing derives test cases to execute specific decision outcomes, normally to increase decision coverage.

Decision Coverage

$$\text{Decision Coverage} = \frac{\text{Number of decision outcomes exercised}}{\text{Total number of decision outcomes}} \text{ X } 100\%$$

- A decision is a statement (If, Do-While, Repeat-Until, Case) where there are 2 or more possible exits/outcomes from the statement.
- Decision coverage is stronger than statement coverage: 100% decision coverage guarantees 100% statement coverage, but not vice versa.

Decision Coverage

Example:

Let's look at a code sample below:

1. READ A
2. READ B
3. C = A - 2*B
4. IF C < 0 THEN
5. PRINT "C negative"
6. END

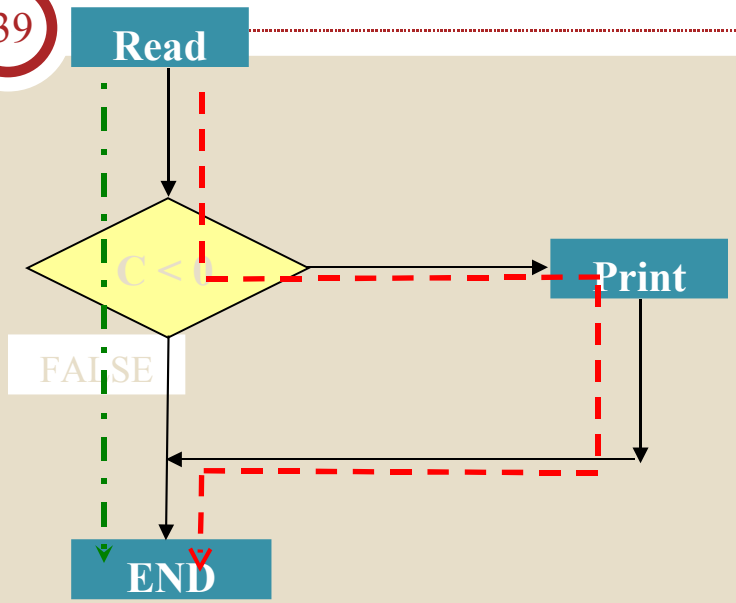
We'll have 1 test:

A=20, B=15

Decision Coverage

- Decision Coverage:
  Test 1: A=20, B=15

  ⇒ 50% (1/2 decisions)



- Increase coverage to 100% ?

  ⇒ Test 2: A=10, B=2

Pseudo-code:

```
READ A
READ B
C = A - 2*B
IF C < 0 THEN
    PRINT "C negative"
END
```

Other White-box Techniques

- Some other white-box techniques:
  - Branch coverage = Decision coverage
  - Condition coverage: Atomic condition coverage
  - Multiple condition coverage: Combinations of atomic conditions

4.5 Experience-based techniques (K2)

- Objectives:
  - LO-4.5.1 Recall reasons for writing test cases based on intuition, experience and knowledge about common defects. (K1)
  - LO-4.5.2 Compare experience-based techniques with specification-based testing techniques.(K2)

4.5 Experience-based techniques (K2)

- Experienced-based testing is where tests are derived from the tester's skill and intuition and their experience with similar applications and technologies.

- Experience-based techniques are used to complement white-box and black-box techniques and are also used when there is no specification is inadequate or out of date.

Error Guessing

- Error guessing is a test technique where the experience of the tester is used to:
  - Anticipate what defects might be present in the system under test as a result of errors made
  - Design tests specifically to expose these defects
- The defect and failure lists can be built based on:
  - Tester's experience
  - Available defects and failure data
  - Common knowledge about why software fails

Error Guessing

- Some samples of error situations:
  - Initialization of data
  - Wrong kind of data
  - Handling of real data
  - Error management
  - Restart/Recovery
  - Proper handling of concurrent procedure

Exploratory Testing

- Exploratory testing is a test technique where the tester:
  - Actively controls the design of the tests as those tests are performed
  - Uses information gained while testing to design new and better tests.
- This is an approach that is most useful where:
  - There are few or inadequate specifications and severe time pressure
  - Or in order to complement other, more formal testing.

4.6 Choosing test techniques (K2)

- Objectives:
  - LO-4.6.1 List the factors that influence the selection of the appropriate test design technique for a particular kind of problem, such as the type of system, risk, customer requirements, models for use case modeling, requirements models or tester knowledge. (K2)

4.6 Choosing test techniques (K2)

- The choice of which test techniques to use depends on a number of factors:
  - The Type of System
  - Regulatory Standards
  - Customer or Contractual Requirements
  - Level of risk, Type of Risk
  - Test Objective
  - Documentation Available
  - Knowledge of Testers
  - Time and Budget
  - Development Life Cycle...

Summary

- Each test technique has its own benefit:
  - Black-box techniques can find parts of the specification that are missing from the code.
  - White-box techniques can find things in the codes that aren't supposed to be there.
  - Experience-based techniques can find things missing from the code and the specification.
- Using a variety of techniques will help ensure that a variety of defects are found.

References

ISTQB International Software Testing Qualifications Board

- Rex Black, Foundations of Software Testing
- ISTQB Foundation Syllabus.pdf
- Slides Software Testing Techniques from TTC

Q & A

Glossary

- **Test basis:** All documents from which the requirements of a component or system can be inferred. The documentation on which the test cases are based. If a document can be amended only by way of formal amendment procedure, then the test basis is called a frozen test basis.
- **Test case:** A set of input values, execution preconditions, expected results and execution postconditions, developed for a particular objective or test condition, such as to exercise a particular program path or to verify compliance with a specific requirement.
- **Test case specification:** A document specifying a set of test cases (objective, inputs, test actions, expected results, and execution preconditions) for a test item.

Glossary

- **Test design specification:** A document specifying the test conditions (coverage items) for a test item, the detailed test approach and identifying the associated high level test cases.
- **Test design technique:** Procedure used to derive and/or select test cases.
- **Test execution:** The process of running a test on the component or system under test,
- producing actual result(s).
- **Test implementation:** The process of developing and prioritizing test procedures, creating test data and, optionally, preparing test harnesses and writing automated test scripts
- **Test procedure specification:** A document specifying a sequence of actions for the execution of a test. Also known as test script or manual test script.

Glossary

- **Test specification:** A document that consists of a test design specification, test case specification and/or test procedure specification.
- **Specification:** A document that specifies, ideally in a complete, precise and verifiable manner, the requirements, design, behavior, or other characteristics of a component or system, and, often, the procedures for determining whether these provisions have been satisfied. [After IEEE 610]
- **Specification-based testing:** See black box testing.
- **Specification-based technique**: See black box test design technique.
- **Specification-based test design technique:** See black box test design technique.

Glossary

- **Black-box technique:** See black box test design technique.
- **Black-box testing:** Testing, either functional or non-functional, without reference to the internal structure of the component or system.
- **Black-box test design technique:** Procedure to derive and/or select test cases based on an analysis of the specification, either functional or non-functional, of a component or system without reference to its internal structure.

Glossary

- **Structure-based testing:** See white-box testing.
- **Structure-based technique:** See white box test design technique.
- **White-box test design technique:** Procedure to derive and/or select test cases based on an analysis of the internal structure of a component or system.
- **White-box testing:** Testing based on an analysis of the internal structure of the component or system.