Test design: Part I

Software Testing: INF3121 / INF4121

Summary: Week 4

Test development process

Analysis / Design / Implementation

Categories of test design techniques

Static / Dynamic

Specification-based testing (black-box)

Equivalence partitioning / Boundary value analysis

Decision table testing

State transition testing

Part I: Close-ended questions

Question 1

In which document described in IEEE 829 would you find instructions for the steps to be taken for a test including set-up, logging, environment and measurement?

a. Test plan
b. Test design specification
c. Test case specification
d. Test procedure specification

Question 1: Answer

In which document described in IEEE 829 would you find instructions for the steps to be taken for a test including set-up, logging, environment and measurement?

- IEEE → Institute of Electrical and Electronics Engineers ("*I triple E*")
- IEEE 829
  - Standard for Software and System Test Documentation
  - Specifies format of documents used in software / system testing
  - 10 documents in total

Question 1: Answer

In which document described in IEEE 829 would you find instructions for the steps to be taken for a test including set-up, logging, environment and measurement?

Master Test Plan (MTP)	Level Test Log (LTL)
Level Test Plan (LTP)	Anomaly Report (AR)
Level Test Design (LTD)	Level Interim Test Status Report (LITSR)
Level Test Case (LTC)	Level Test Report (LTR)
Level Test Procedure (LTPr)	Master Test Report (MTR)

Question 1: Answer

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Level Test Design (LTD)	Level Interim Test Status Report (LITSR)
Level Test Case (LTC)	Level Test Report (LTR)
Level Test Procedure (LTPr)	Master Test Report (MTR)

Question 1: Answer

In which document described in IEEE 829 would you find instructions for the steps to be taken for a test including set-up, logging, environment and measurement?

- Master Test Plan (MTP)
  - Scope, system overview, organisation
  - Responsibilities, tools, techniques, methods
- Level Test Plan (LTP)
  - Like MTP but specific for each level of testing
  - Scope, resources, schedule of the testing activities

Question 1: Answer

In which document described in IEEE 829 would you find instructions for the steps to be taken for a test including set-up, logging, environment and measurement?

- Level Test Design (LTD)
  - Detailing test cases → Identify features to be tested
  - Expected results
- Level Test Case (LTC)
  - Objectives
  - Inputs / Outputs

Question 1: Answer

In which document described in IEEE 829 would you find instructions for the steps to be taken for a test including set-up, logging, environment and measurement?

- Level Test Procedure (LTPr)
  - Detailed account of how to run each test
  - Description of each step to be taken to execute test cases
    - Set-up: Sequence of necessary actions to prepare for test execution
    - Log: List tools / methods for logging results
    - Environment: Describe environment for test execution
    - Measurement: Describe how test measurements will be made

Question 1: Answer

In which document described in IEEE 829 would you find instructions for the steps to be taken for a test including set-up, logging, environment and measurement?

a. Test plan
b. Test design specification
c. Test case specification
d. Test procedure specification

Question 2

With a highly experienced tester with a good business background, which approach to defining test procedures would be effective and most efficient for a project under severe time pressure?

a. A high-level outline of the test conditions and general steps to be taken
b. Every step in the test spelled out in detail
c. A high-level outline of the test conditions with the steps to take discussed in detailed with another experienced tester
d. Detailed documentation of all test cases and careful records of each step taken in testing

Question 2: Answer

With a highly experienced tester with a good business background, which approach to defining test procedures would be effective and most efficient for a project under severe time pressure?

- Test effort under severe time pressure
  - Not feasible to define test procedures in full detail
  - Experience-based testing
    - Take advantage of the experience of the tester
    - Previous experience → Insights to what could go wrong
- Possible solution
  - High-level outline of test condition + General steps to be taken

Question 2: Answer

With a highly experienced tester with a good business background, which approach to defining test procedures would be effective and most efficient for a project under severe time pressure?

a. **A high-level outline of the test conditions and general steps to be taken**
b. Every step in the test spelled out in detail
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d. Detailed documentation of all test cases and careful records of each step taken in testing

Question 3

Put the test cases that implement the following test conditions into the best order for the test execution schedule, for a test that is checking modifications of customers on a database.

1) Print modified customer record
2) Change customer address: House number and street name
3) Capture and print the on-screen error message
4) Change customer address: Postal code
5) Confirm existing customer is on the database by opening that record
6) Close the customer record and close the database
7) Try to add a new customer with no details at all

a. 5, 4, 2, 1, 3, 7, 6
b. 4, 2, 5, 1, 6, 7, 3
c. 5, 4, 2, 1, 7, 3, 6
d. 5, 1, 2, 3, 4, 7, 6

Question 3: Answer

Put the test cases that implement the following test conditions into the best order for the test execution schedule, for a test that is checking modifications of customers on a database.

Activities

1. **Print** modified customer record
2. **Change** customer **address**: House number and street name
3. **Capture** and print the on-screen **error message**
4. **Change** customer **address**: Postal code
5. **Confirm** existing **customer** is in the database by **opening** that record
6. **Close** the customer **record** and close the **database**
7. **Try** to **add** a new **customer** with **no details** at all

Question 3: Answer

Put the test cases that implement the following test conditions into the best order for the test execution schedule, for a test that is checking modifications of customers on a database.

Activities: Simplified

1. **Print** modified record
2. **Change address**
3. **Capture error message**
4. **Change address**
5. **Confirm customer** by **opening** record
6. **Close record** and close **database**
7. **Try** to **add** new **customer** with **no details**

Question 3: Answer

Put the test cases that implement the following test conditions into the best order for the test execution schedule, for a test that is checking modifications of customers on a database.

Execution schedule for checking modifications

- What is the most intuitive order for customer record modification?
  - **Find** customer
  - **Modify** customer record
  - **Verify** modification
  - Create blank (provoke **error**)
  - **Verify** error
  - **Close** record + database

Question 3: Answer

Put the **test cases** that implement the following test conditions into the **best order** for the test **execution schedule**, for a test that is **checking modifications** of **customers** on a **database**.

Execution schedule for checking modifications

Find customer	5. Confirm existing customer by opening record
Modify customer records	4. Change address: Postal code
	2. Change address: House number + Street
Verify modification	1. Print modified record
Create blank (provoke error)	7. Try to add new customer, no details
Verify error	3. Capture error message
Close record + database	6. Close record + database

Question 3: Answer

Put the test cases that implement the following test conditions into the best order for the test execution schedule, for a test that is checking modifications of customers on a database.

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b. 4, 2, 5, 1, 6, 7, 3
c. 5, 4, 2, 1, 7, 3, 6
d. 5, 1, 2, 3, 4, 7, 6

Question 4

Why are both specification-based and structure-based testing techniques useful?

a. They find different types of defects
b. Using more techniques is always better
c. Both find the same types of defect
d. Because specifications tend to be unstructured

Question 4: Answer

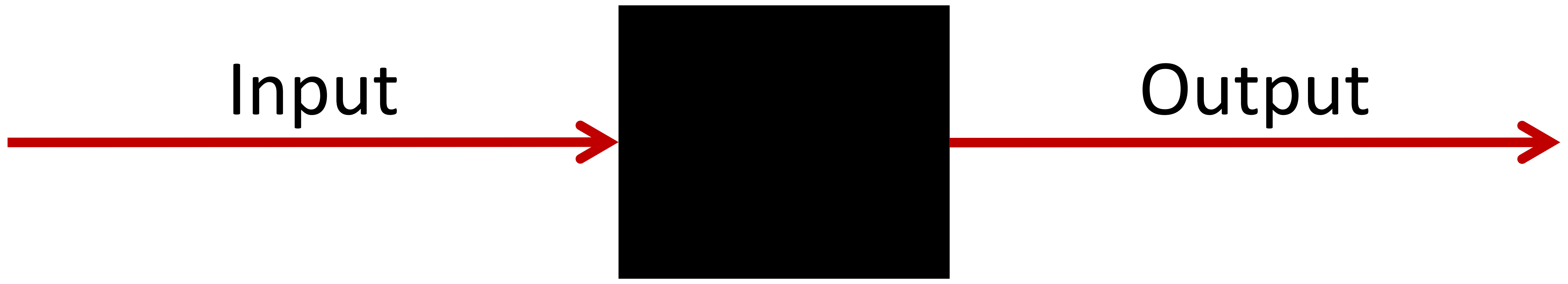
Why are both specification-based and structure-based testing techniques useful?

Specification-based testing (Black-box testing)

Views software as a black box with inputs and outputs

Testers have *no knowledge* of how the system looks inside

Examines the functionality without looking into the internal structure

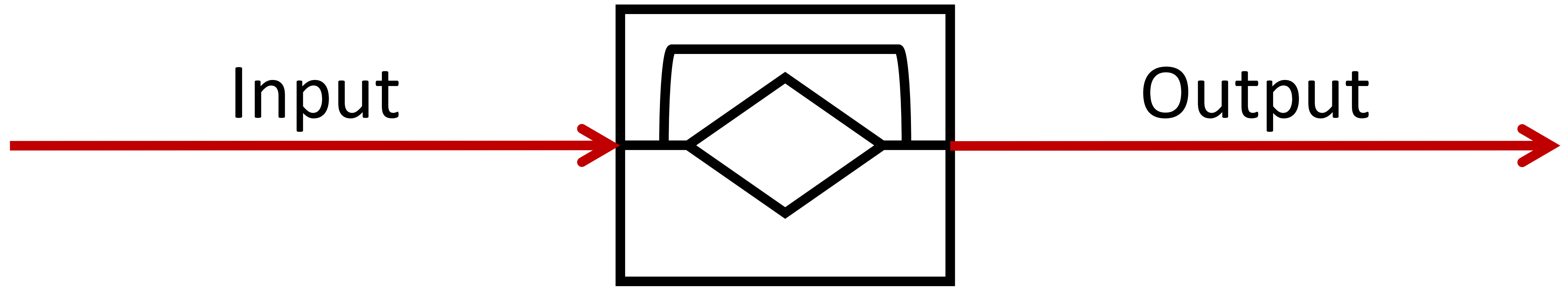


Question 4: Answer

Why are both specification-based and structure-based testing techniques useful?

Structure-based testing (White-box testing)

- Testers *require knowledge* of how the software is implemented
- Testers ask the question: *How* does the software do it?
- Examines the structure by looking into the program logic



Question 4: Answer

Why are both specification-based and structure-based testing techniques useful?

a. **They find different types of defects**
b. Using more techniques is always better
c. Both find the same types of defect
d. Because specifications tend to be unstructured

Question 5

What is a key characteristic of structure-based testing techniques?

a. They are mainly used to assess the structure of a specification
b. They are used both to measure coverage and to design tests to increase coverage
c. They are based on the skills and experience of the tester
d. They use a formal or informal model of the software or component

Question 5: Answer

What is a key characteristic of structure-based testing techniques?

- Overall objectives of testing
  - Find defects / Gain confidence in the system
- Question: How?
  - Testing as much as possible / feasible
- Concern
  - How to assess the thoroughness of the test effort
  - How much have we tested? How many aspects of the system have been checked?

Question 5: Answer

What is a key characteristic of structure-based testing techniques?

Solution

- Assess thoroughness of test effort through coverage

Approach: Structure-based techniques

- Advantage: We have access to the code!
- Examine code / internal structure of the software
- Insight into logic / states / system architecture

Question 5

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c. They are based on the skills and experience of the tester

d. They use a formal or informal model of the software or component

Question 6

Should pre-conditions and post-conditions be part of a test case?

a. Yes
b. No

Question 6: Answer

Should pre-conditions and post-conditions be part of a test case?

- Test case (cf. IEEE 829)
  - Inputs
  - Execution conditions (pre- and post-conditions)
  - Expected / Predicted results
- Developed for a particular objective
  - Exercise particular program / functionality
  - Verify compliance with specific requirement(s)

Question 6: Answer

Should pre-conditions and post-conditions be part of a test case?

- The need for test conditions
  - When can we start a test? / When does a test end?
  - What conclusions can we derive from a test? / What does the test tell us?
- Pre-conditions
  - Condition(s) that must be in place PRIOR to running the test
- Post-conditions
  - Condition(s) that must be in place AFTER running the test

Question 6: Answer

Should pre-conditions and post-conditions be part of a test case?

a. **Yes**
b. No

Question 7

__________ is the analysis at the edge of each equivalence partition.

We apply this test design technique because at the edges of equivalence partitions, the results are more likely to be incorrect.

Question 7: Answer

__________ is the analysis at the edge of each equivalence partition.

- Equivalence partitioning
  - Idea: Divide test conditions into groups that can be considered the same
  - These groups are equivalent
  - Test only one condition from each partition
    - Assume all conditions in the same partition will be treated the same
    - Little point in testing all values in the partition
- Simplified assumptions → Not always right

Question 7: Answer

__________ is the analysis at the edge of each equivalence partition.

Example: Public transport ticket prices

Children (under the age of 15):	20 NOK for a single ticket
Students (between 15 and 25):	25 NOK for a single ticket
Adults:	35 NOK for a single ticket
Seniors (over the age of 65):	20 NOK for a single ticket

Equivalence partitioning

E.g. We can assume that individuals of age 67, 68, 74, 88 are treated the *same*

Hence, when testing for senior discount → Do not have to test all ages

Question 7: Answer

__________ is the analysis at the edge of each equivalence partition.

- Example: Public transport ticket prices
  - Question: What is the right price for persons of age:
    - 15 years / 25 years / 65 years?
  - Specifications may be unclear
- Boundary value analysis (BVA)
  - Testing the boundaries (min. and max. values) / edges of equivalence partitions
  - High defect-finding capability

Question 7: Answer

__________ is the analysis at the edge of each equivalence partition.

BVA – Boundary Value Analysis

Question 8

Which of the following would be an example of decision-table testing for a financial application applied at system-test level?

a. A table containing rules for combination of inputs to two fields on the screen
b. A table containing rules for interfaces between components
c. A table containing rules for mortgage applications
d. A table containing rules for chess

Question 8: Answer

Which of the following would be an example of decision-table testing for a financial application applied at system-test level?

- Decision-table testing
  - Cause-Effect table
  - Different combinations of input result in different actions
  - Aids in identifying effective test cases
  - Can reveal ambiguities in the specification
  - Explores business rules

Conditions	R1	R2	R3	R4
Student enrolled in course	T	T	F	F
Mandatory exercises passed	T	F	T	F
Actions				
Can write exam	T	F	F	F

Question 8: Answer

Which of the following would be an example of decision-table testing for a financial application applied at system-test level?

- System testing
  - Concerned with the behaviour of the entire system
  - High-level descriptions of system behaviour
  - Often final testing phase on behalf of development
- Hence:
  - We are interested in testing an overall / main aspect of the system

Question 8: Answer

Which of the following would be an example of decision-table testing for a financial application applied at system-test level?

a. A table containing rules for combination of inputs to two fields on the screen
b. A table containing rules for interfaces between components
c. **A table containing rules for mortgage applications**
d. A table containing rules for chess

Question 9

Which of the following could be a coverage measure for state transition testing?

V. All states have been reached
W. The respond time for each transition is adequate
X. Every transition has been executed
Y. All boundaries have been exercised
Z. Specific sequences of transitions have been exercised

a. X, Y and Z
b. V, X, Y and Z
c. W, X and Y
d. V, X and Z

Question 9: Answer

Which of the following could be a coverage measure for state transition testing?

- Test coverage
  - Measure of the amount of testing performed by a set of tests
  - Simplified: How much of the code has been tested?
  - Aim: Reveal test coverage + Design additional tests to increase coverage
- Coverage measure
  - How can we measure the coverage of the test effort?
  - What approaches / artefacts can be used to determine coverage?

Question 9: Answer

Which of the following could be a coverage measure for state transition testing?

State-transition testing

- Some aspect of the system can be described in a “finite state machine”
- System can be in a *finite* number of different states
- Transitions from one state to another depend on the *rules* of the machine

State diagram

- Describes the behaviour of the system
- Illustrates the different states a system can be in + Transitions between states

Question 9: Answer

Which of the following could be a coverage measure for state transition testing?

Example: State diagram for PIN entry in ATM

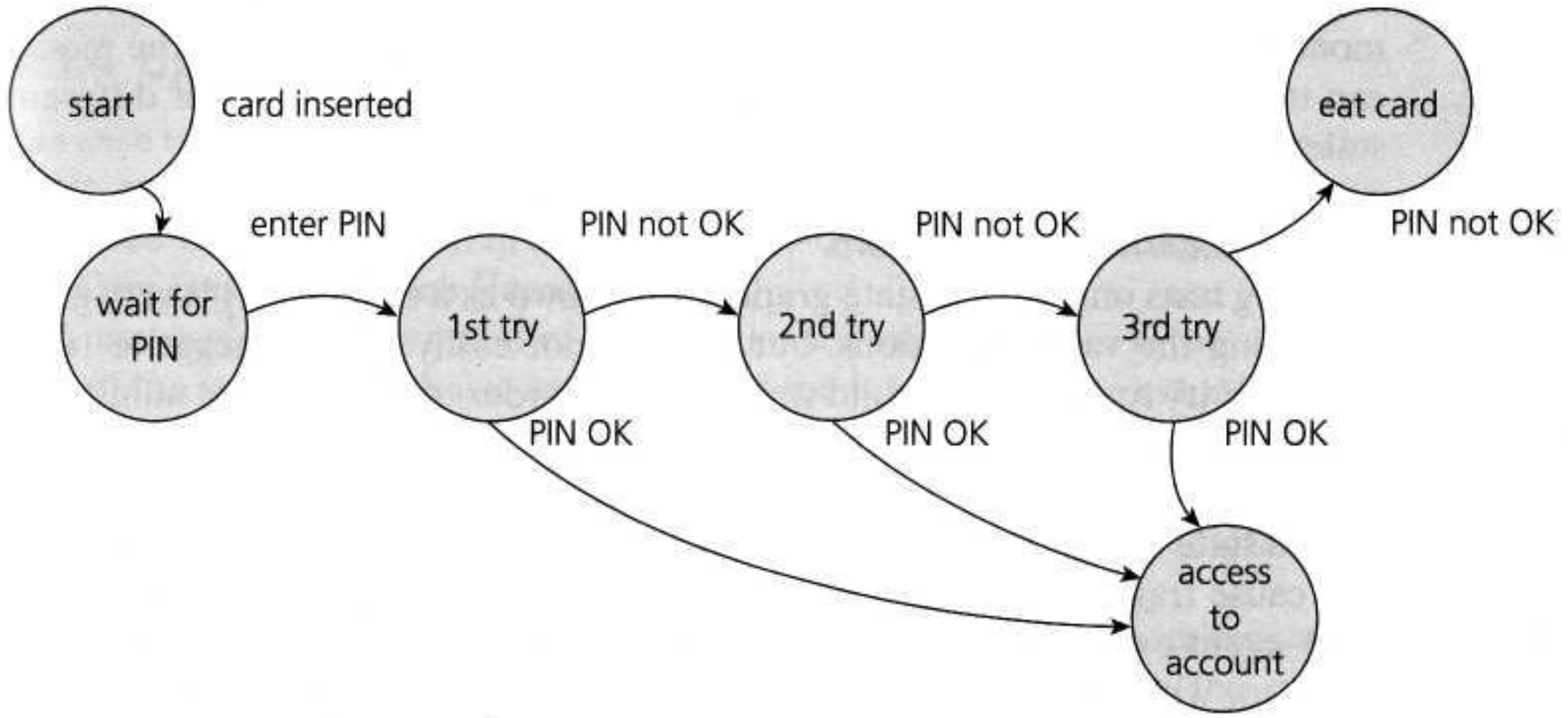
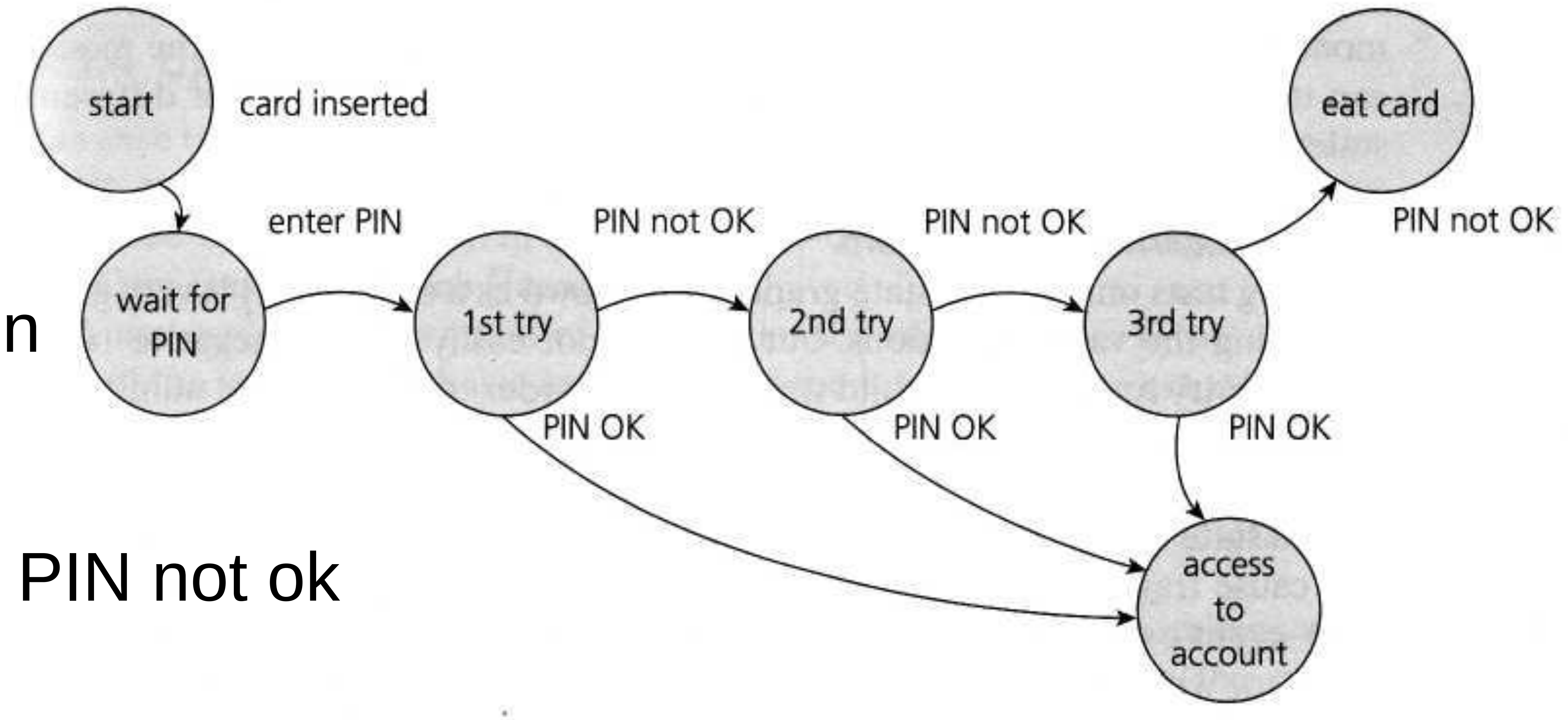


Figure 4.2 in textbook

Question 9: Answer

Which of the following could be a coverage measure for state transition testing?

- Example: State diagram for PIN entry in ATM
  - States software may be in
    - Shown in circles
  - Transitions from one state to another
    - Arrows pointing to the next transition
  - Events causing the transitions
    - Card inserted / Enter PIN / PIN ok / PIN not ok
  - Actions resulting from transitions



Question 9: Answer

Which of the following could be a coverage measure for state transition testing?

- State transition testing and coverage
  - When using state transition testing → What can measure coverage?
    - The number of states reached
    - Specific sequences of transitions exercised
    - Every transition has been executed
  - All of the above tell us about the amount of testing performed through state transition
- However: What about testing all boundaries / boundary values?

Question 9: Answer

Which of the following could be a coverage measure for state transition testing?

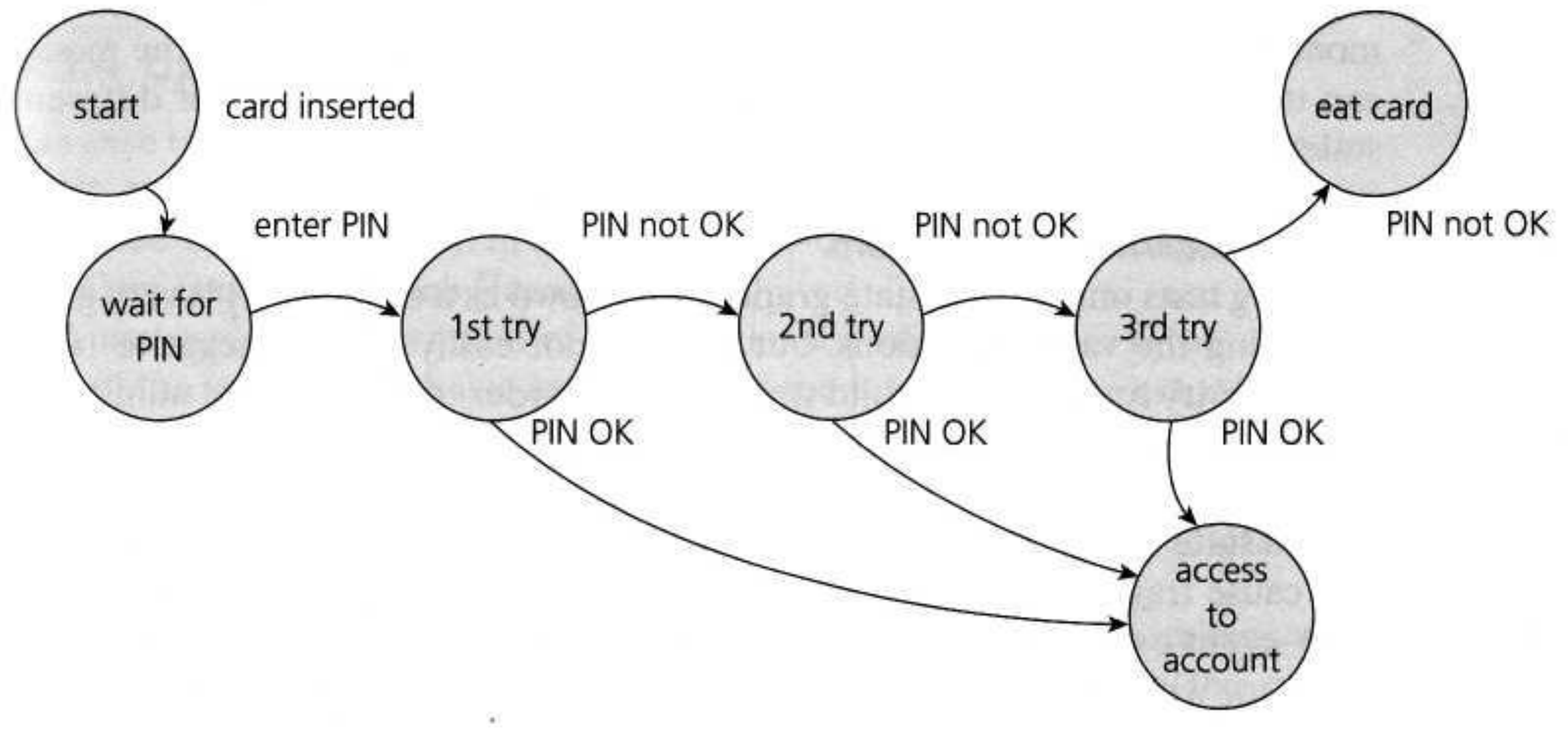
- Testing boundary values
  - Indeed a measure of testing coverage
  - Tells us about the percentage of boundaries exercised
- However: *Not* a coverage measure for state transition testing
  - Testing boundary values does not necessarily tell us anything about state transitions
  - Boundary values may only be relevant for certain states
  - Example: We refer back to the ATM state diagram

Question 9: Answer

Which of the following could be a coverage measure for state transition testing?

Example: State diagram for PIN entry in ATM

- Can test all PIN number boundaries
  - 0000 – 9999
  - Less than four digits
  - More than four digits
- Not directly linked to state transitions



Question 9: Answer

Which of the following could be a coverage measure for state transition testing?

V. All states have been reached
W. The respond time for each transition is adequate
X. Every transition has been executed
Y. All boundaries have been exercised
Z. Specific sequences of transitions have been exercised

a. X, Y and Z
b. V, X, Y and Z
c. W, X and Y
d. V, X and Z

Question 10

Which of the following could be used to assess the coverage achieved for specification-based test techniques?

V.	Decision outcomes exercised
W.	Partitions exercised
X.	Boundaries exercised
Y.	State transitions exercised
Z.	Statements exercised

a. V, W, Y or Z
b. W, X or Y
c. V, X or Z
d. W, X, Y or Z

Question 10: Answer

Which of the following could be used to assess the coverage achieved for specification-based test techniques?

- Specification-based test techniques
  - Views software as a black box
  - No knowledge of how the system is internally structured
  - Concern: What the system does, not how it does it
- Assessing coverage
  - Partitions exercised / Boundaries exercised / State transitions exercised
- Decisions + Statements exercised → Internal structure
  - Structure-based techniques (white box)

Question 10: Answer

Which of the following could be used to assess the coverage achieved for specification-based test techniques?

V. Decision outcomes exercised
W. Partitions exercised
X. Boundaries exercised
Y. State transitions exercised
Z. Statements exercised

a. V, W, Y or Z
b. W, X or Y
c. V, X or Z
d. W, X, Y or Z

Part II: Exercises and Open-ended questions

Exercise I: Equivalence Partitioning

Postal rates for ‘light letters’ are 25 NOK up to 10g, 35 NOK up to 50g, plus an extra 10 NOK for each additional 25g up to 100g.
Which test inputs (in grams) would be selected using equivalence partitioning?

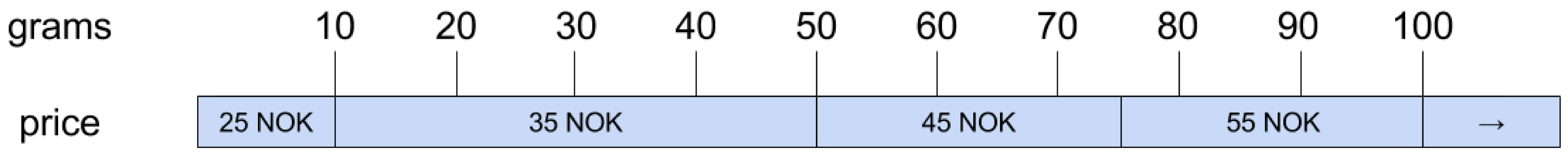
a. 8, 42, 82, 102
b. 4, 15, 65, 92, 159
c. 10, 50, 75, 100
d. 5, 20, 50, 60, 80

Exercise I: Answer

Which test inputs (in grams) would be selected using equivalence partitioning?

Scenario

How are postal rates calculated?

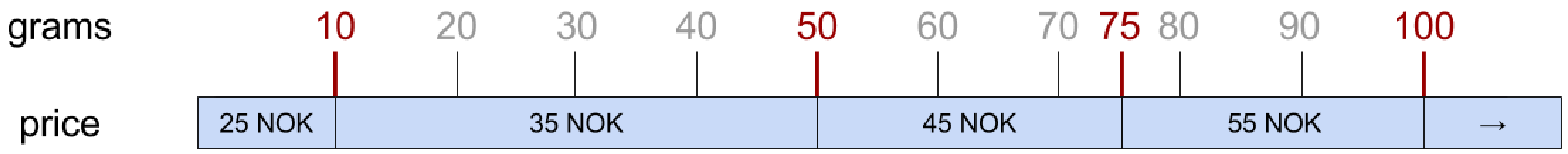


Exercise I: Answer

Which **test inputs** (in grams) would be **selected** using **equivalence partitioning**?

Questions

What are the key boundaries? / How many values do we need?

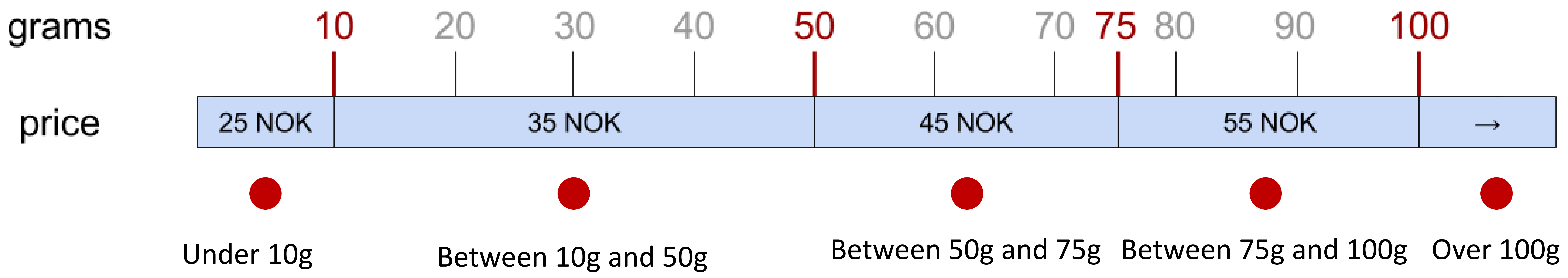


Exercise I: Answer

Which test inputs (in grams) would be selected using equivalence partitioning?

Answer

We need five test inputs → Each in their own equivalence class

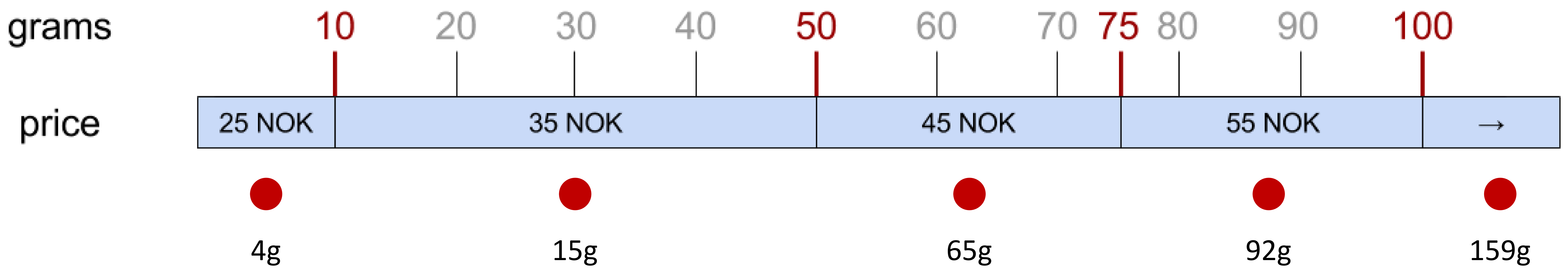


Exercise I: Answer

Which **test inputs** (in grams) would be **selected** using **equivalence partitioning**?

Answer

We choose five arbitrary values for each equivalence class



Exercise I: Answer

Postal rates for ‘light letters’ are 25 NOK up to 10g, 35 NOK up to 50g, plus an extra 10 NOK for each additional 25g up to 100g.
Which **test inputs** (in grams) would be **selected** using **equivalence partitioning**?

a. 8, 42, 82, 102
b. 4, 15, 65, 92, 159
c. 10, 50, 75, 100
d. 5, 20, 50, 60, 80

Exercise II

If you take the train before 9:30 AM or in the afternoon after 4:00 PM until 7:30 PM ('rush hour') you must pay full fare. A saver ticket is available for trains between 9:30 AM and 4:00 PM, and after 9:30 PM.

What are the partitions and boundary values to test the train times for this ticket types?

Which are valid partitions and which are invalid partitions?

What are the boundary values? (A table may be useful)

Derive test cases for the partitions and boundaries.

Do you have any questions about this 'requirement'?
Is anything unclear?

Exercise II: Answer

Approach

- Establish the exact boundaries between full fare and saver fare.
- We can use a table to map out the information given:
  - Departure time of train
  - Corresponding ticket type for the departure time
    - Saver ticket
    - Full fare ticket

Scheduled Departure time				
Ticket type				

Exercise II: Answer

Approach

"If you take the train before 9:30 am, or in the afternoon after 4:00 pm until 7:30 pm, you must pay full fare."

Scheduled Departure time	≦ 9:29 am		4:01 pm - 7:30 pm	
Ticket type	FULL		FULL	

"A saver ticket is available for trains between 9:30 am and 4:00 pm, and after 7:30 pm."

Scheduled Departure time		9:30 am - 4:00 pm		≧ 7:31 pm
Ticket type		SAVER		SAVER

Exercise II: Answer

Approach

This gives us the following table:

Scheduled Departure time	≦ 9:29 am	9:30 am - 4:00 pm	4:01 pm - 7:30 pm	≧ 7:31 pm
Ticket type	FULL	SAVER	FULL	SAVER

We assume that the boundary values are:

9:29 am, 9:30 am

4:00 pm, 4:01 pm

7:30 pm, 7:31 pm

Benefit of this approach

Our exact interpretation of the specification can reveal ambiguities

Exercise II: Answer

What we have so far:

Saver: Between 9:30 am and 4:00 pm

Full: After 4:00 pm and until 7:30 pm

Ambiguities / Considerations

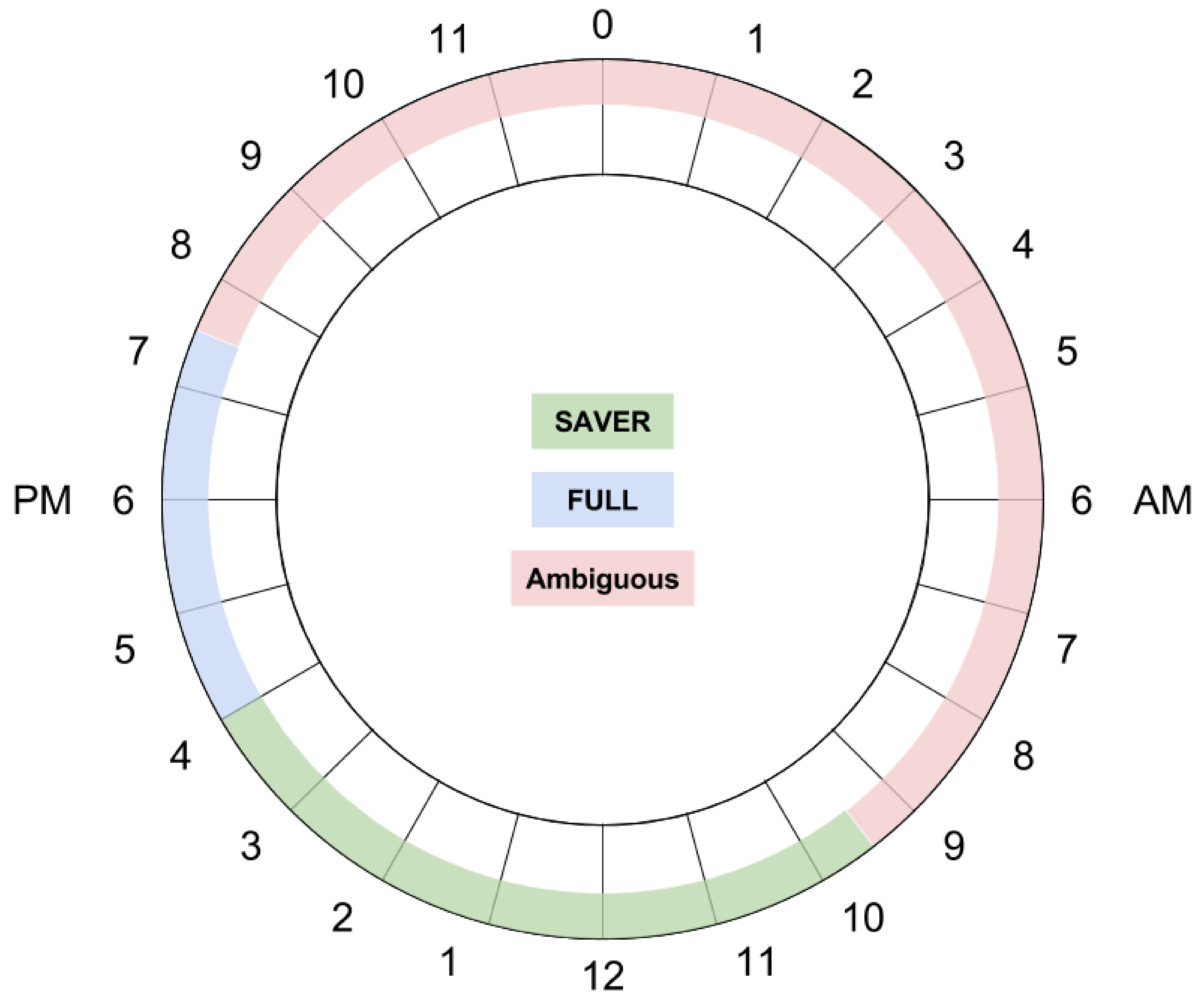
When does the morning "rush hour" start?

At midnight?

At 11:30 the previous day?

At the time of the first train of the day?

The specification is unclear!



Exercise II: Answer

Other considerations

- If a train is scheduled to leave at exactly 4:00 pm
  - Is a saver ticket still valid?
- If a train is scheduled to leave before 4:00 pm, but delayed until after 4:00 pm:
  - Is a saver ticket still valid?

We can make assumptions, but we prefer the “correct” specification!

However, let us work with the information we have.

Exercise II: Answer

Test cases for partitions and boundaries

Test Case ID	Input	Expected outcome
1	Depart 4:30 am	Pay full fare
2	Depart 9:29 am	Pay full fare
3	Depart 9:30 am	Buy saver ticket
4	Depart 11:37 am	Buy saver ticket
5	Depart 4:00 pm	Buy saver ticket
6	Depart 4:01 pm	Pay full fare
7	Depart 5:55 pm	Pay full fare
8	Depart 7:30 pm	Pay full fare
9	Depart 7:31 pm	Buy saver ticket
10	Depart 10:05 pm	Buy saver ticket

Exercise II: Answer

Test cases for partitions and boundaries

- Note: All partitions are valid
- There may be invalid partitions
  - At a time no trains are running?
- Specification does not mention that!

Equivalence partition values

- Test cases: 1, 4, 7, and 10

Boundary values

- Test cases: 2, 3, 5, 6, 8, and 9

Test Case ID	Input	Expected outcome
1	Depart 4:30 am	Pay full fare
2	Depart 9:29 am	Pay full fare
3	Depart 9:30 am	Buy saver ticket
4	Depart 11:37 am	Buy saver ticket
5	Depart 4:00 pm	Buy saver ticket
6	Depart 4:01 pm	Pay full fare
7	Depart 5:55 pm	Pay full fare
8	Depart 7:30 pm	Pay full fare
9	Depart 7:31 pm	Buy saver ticket
10	Depart 10:05 pm	Buy saver ticket

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