Test design: Part II

Software Testing: IN3240 / IN4240

Summary

Specification-based testing (black-box)

Equivalence partitioning | Boundary value analysis

Decision table | State transition | Use case testing

Structure-based testing (white-box)

Statement / Decision testing and coverage

Experience-based testing

Choosing test technique

Part I: Close-ended questions

Question 1

Which of the following would structure-based test design techniques be likely to be applied to?

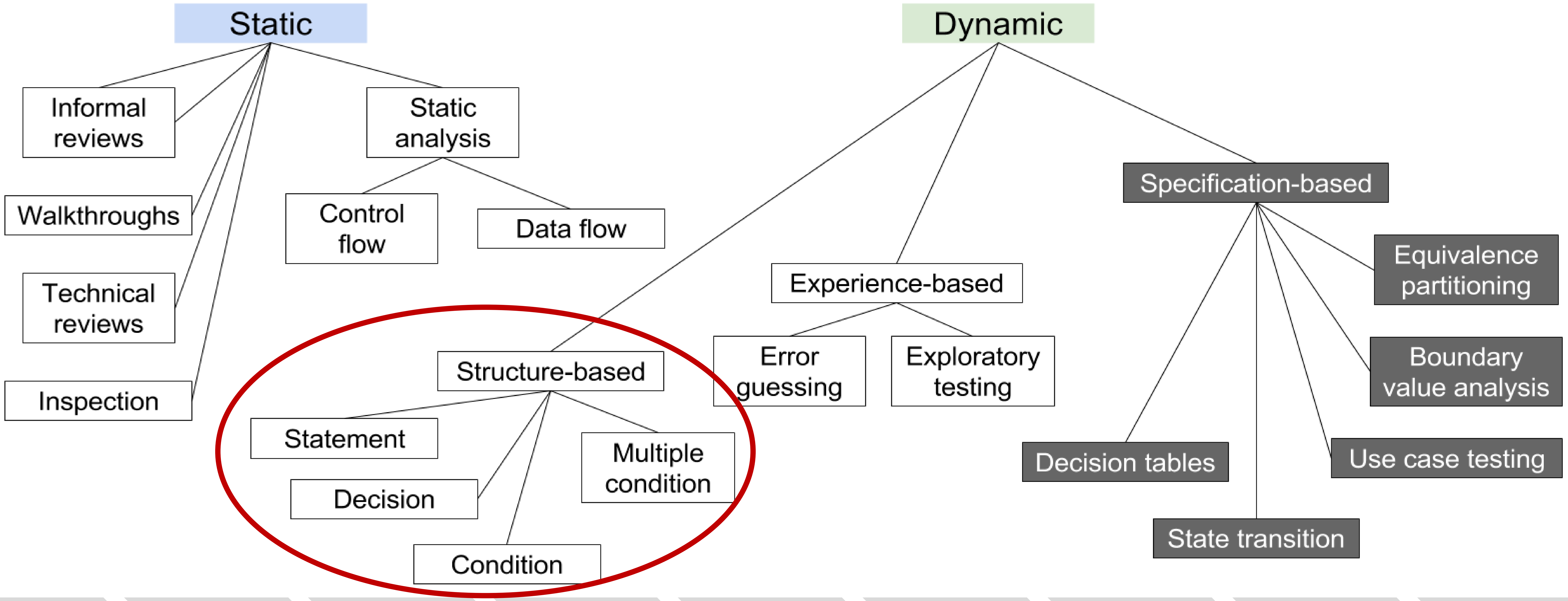
1. Boundaries between mortgage interest rate bands
2. An invalid transition between two different arrears statuses
3. The business process flow for mortgage approval
4. Control flow of the program to calculate repayment

a. 2, 3 and 4
b. 2 and 4
c. 3 and 4
d. 1, 2 and 3

Question 1: Clues

Which of the following would **structure-based** test **design techniques** be likely to be **applied** to?

Different types of testing



Question 1: Clues

Which of the following would structure-based test design techniques be likely to be applied to?

- Purpose of structure-based techniques
  - Test coverage measurement
    - Assess the amount of testing performed by tests
    - Derived from specification-based technique to assess coverage
  - Structural test design
    - Generate additional test cases
    - Increase test coverage

Question 1: Clues

Which of the following would structure-based test design techniques be likely to be applied to?

- Characteristics of structure-based techniques
  - Target: Testing the structure of a system / component
  - White-box testing → What happens inside the box?
  - Can occur at any test level
    - Tends to be applied to component / integration level testing
    - Higher test levels → Business process testing
  - Control flow models
    - Support structural testing

Question 2

Use case testing is useful for which of the following?

1. Designing acceptance tests with users or customers
2. Making sure the mainstream business processes are tested
3. Finding defects in the interaction between components
4. Identifying the maximum and minimum values for every input field
5. Identifying the percentage of statements exercised by a set of tests

a. 1, 2 and 3
b. 2, 4 and 5
c. 1, 2 and 4
d. 3, 4 and 5

Question 2: Clues

Use case testing is useful for which of the following?

Use case testing

- Technique to identify test cases that exercise the whole system
  - Transaction by transaction basis from start to finish
- Sequence of steps → Describes interactions between actor and system
  - Achieve a specific task / Produce something of value to the user
- Defined in terms of the actor, not the system
  - Describes process flows through a system → Based on its actual use
  - Can uncover integration defects → Incorrect actions between components
    - Individual testing would not uncover these

Question 3

Which of the following statements about the relationship between statement and decision coverage is correct?

a. 100 % decision coverage is achieved if statement coverage is greater than 90 %
b. 100 % statement coverage is achieved if decision coverage is greater than 90 %
c. 100 % decision coverage always means 100 % statement coverage
d. 100 % statement coverage always means 100 % decision coverage

Question 3: Clues

Which of the following statements about the relationship between statement and decision coverage is correct?

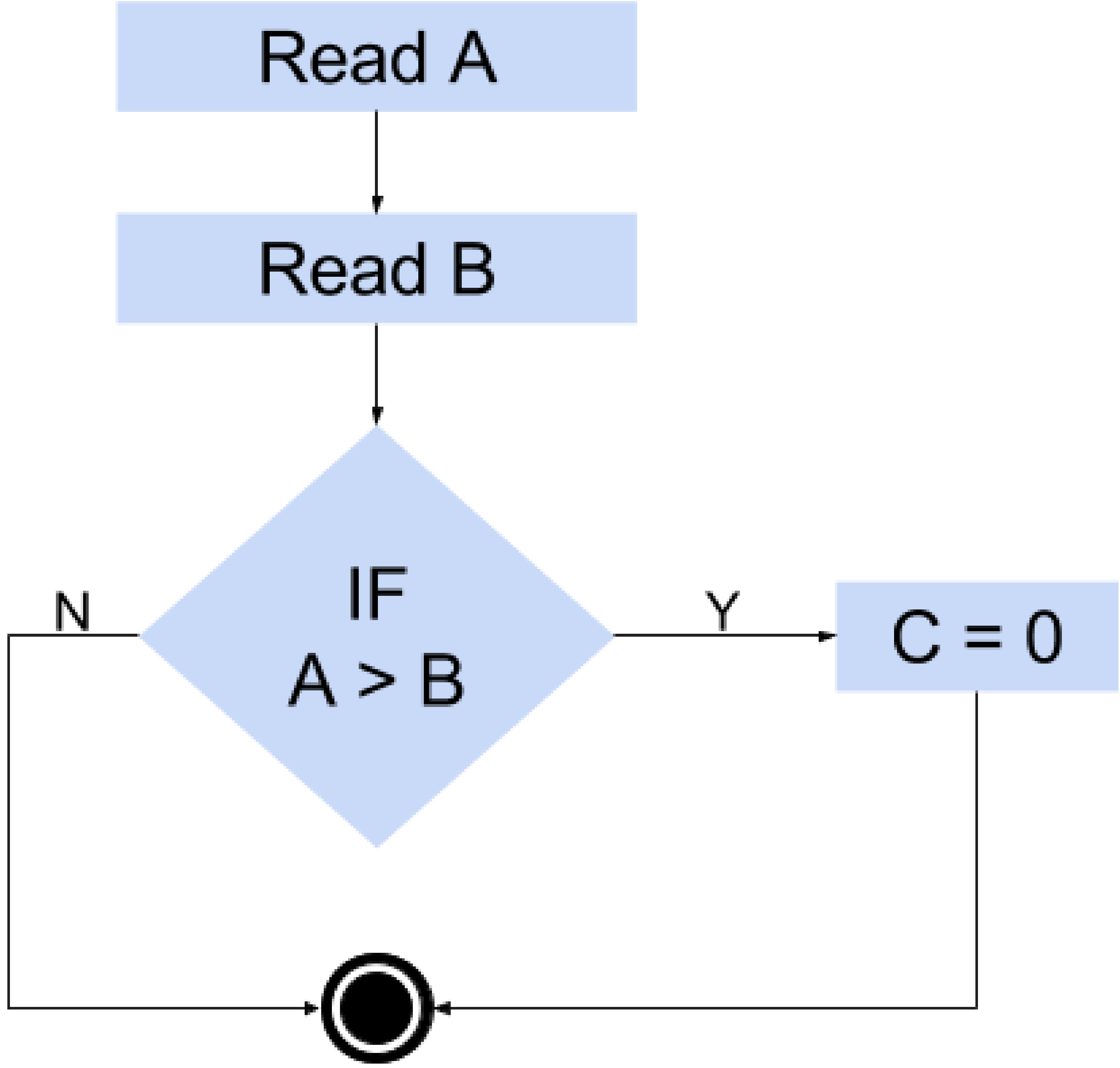
Statement coverage

Code example (each line is a statement)

```
1    READ A
2    READ B
3    IF A > B THEN C = 0
4    ENDIF
```

To achieve 100% statement coverage:

How many test cases needed?



Question 3: Clues

Which of the following statements about the relationship between statement and decision coverage is correct?

Achieving 100 % Statement coverage

Just one test case needed

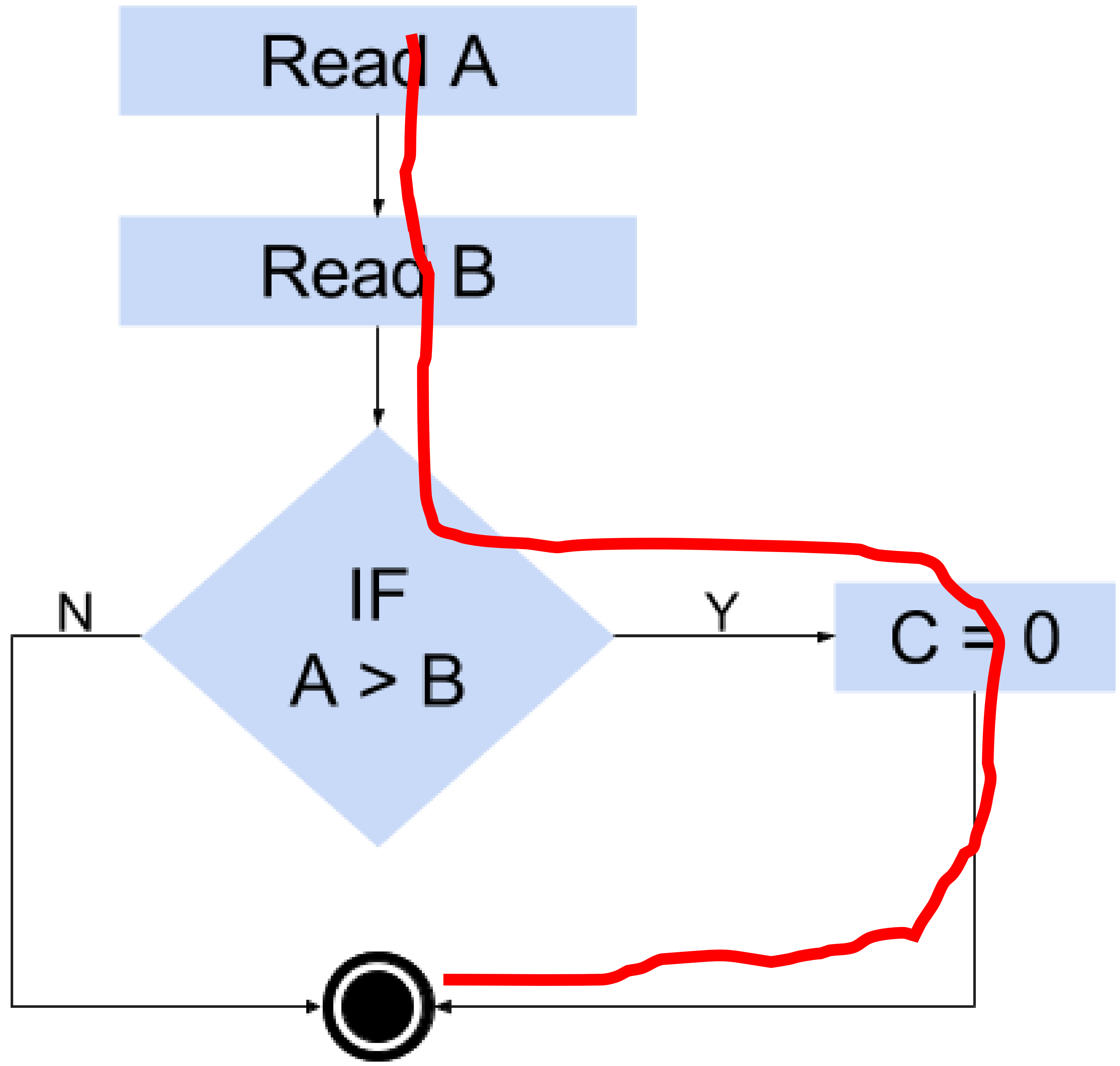
A must be greater than B

Runs through all statements

Example test case

A = 12

B = 10

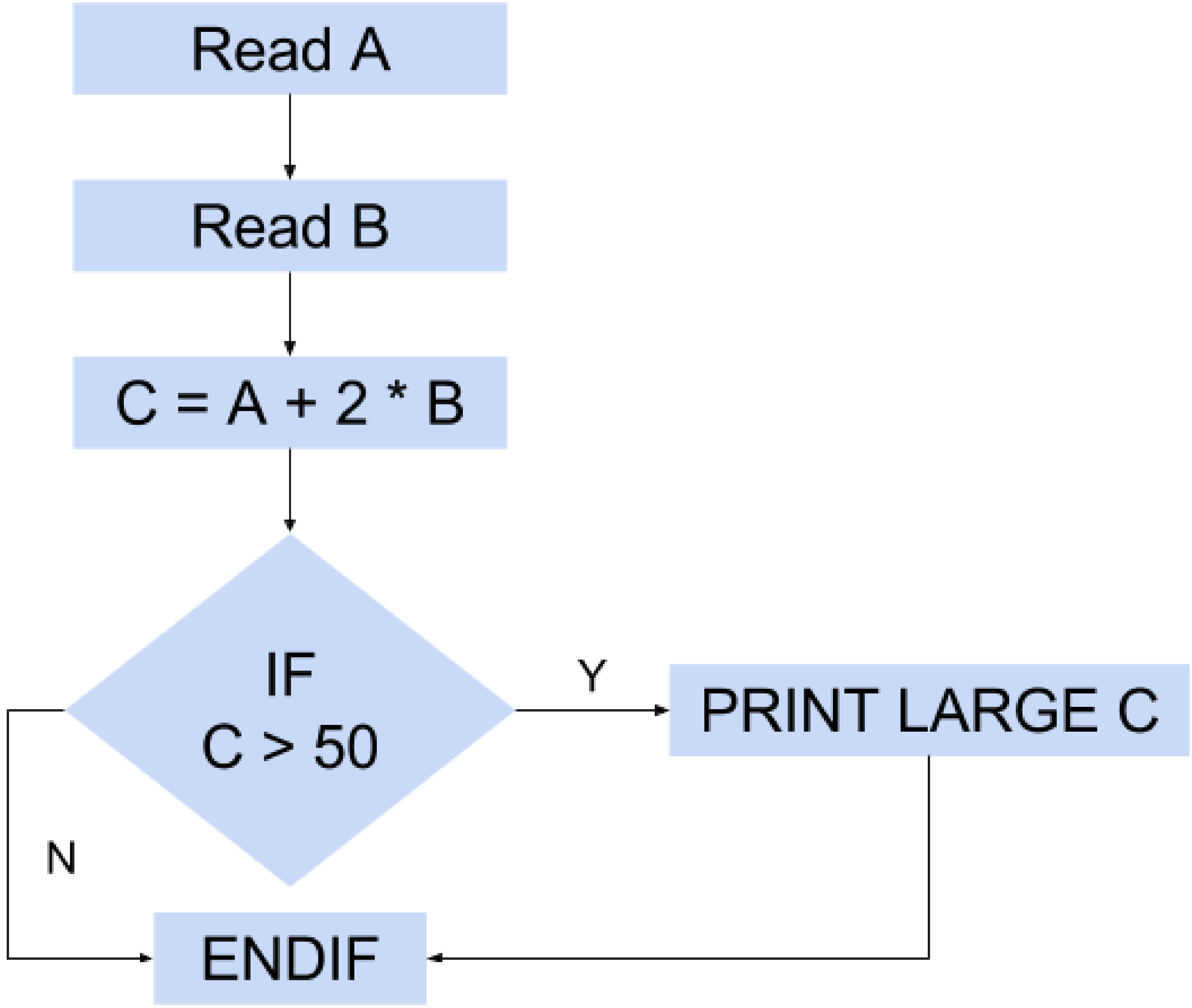


Question 3: Clues

Which of the following statements about the relationship between statement and decision coverage is correct?

Example II: Statement coverage

```
READ A
READ B
C = A + 2 * B
IF C > 50 THEN
PRINT LARGE C
ENDIF
```



Question 3: Clues

Which of the following statements about the **relationship** between **statement** and **decision coverage** is correct?

Example II: Statement coverage

Test 1_1:

A = 2, B = 3

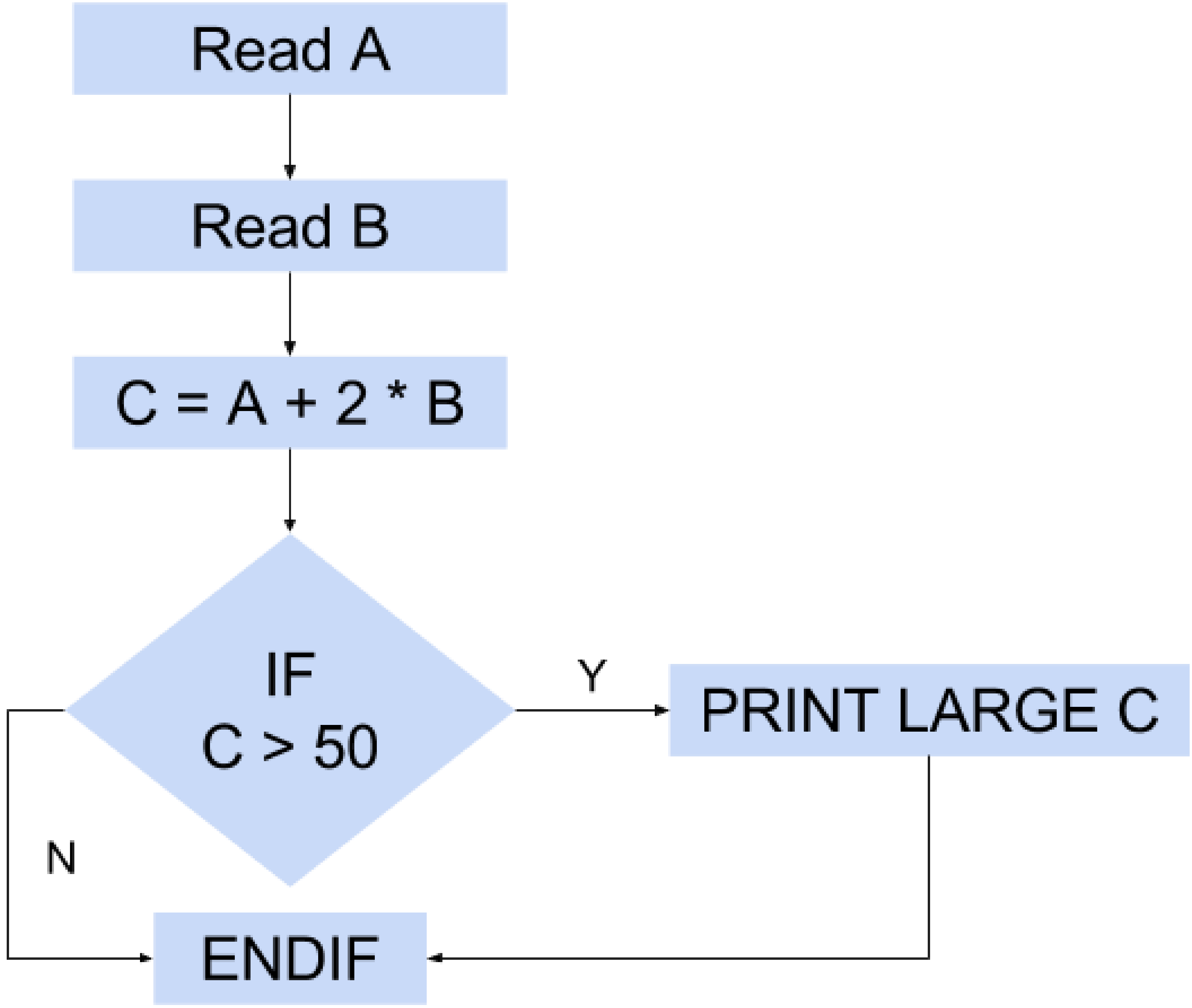
Test 1_2:

A = 0, B = 25

Test 1_3:

A = 47, B = 1

Which statements have we covered?



Question 3: Clues

Which of the following statements about the relationship between statement and decision coverage is correct?

Example II: Statement coverage

Test 1_1:

A = 2, B = 3 // C = 8

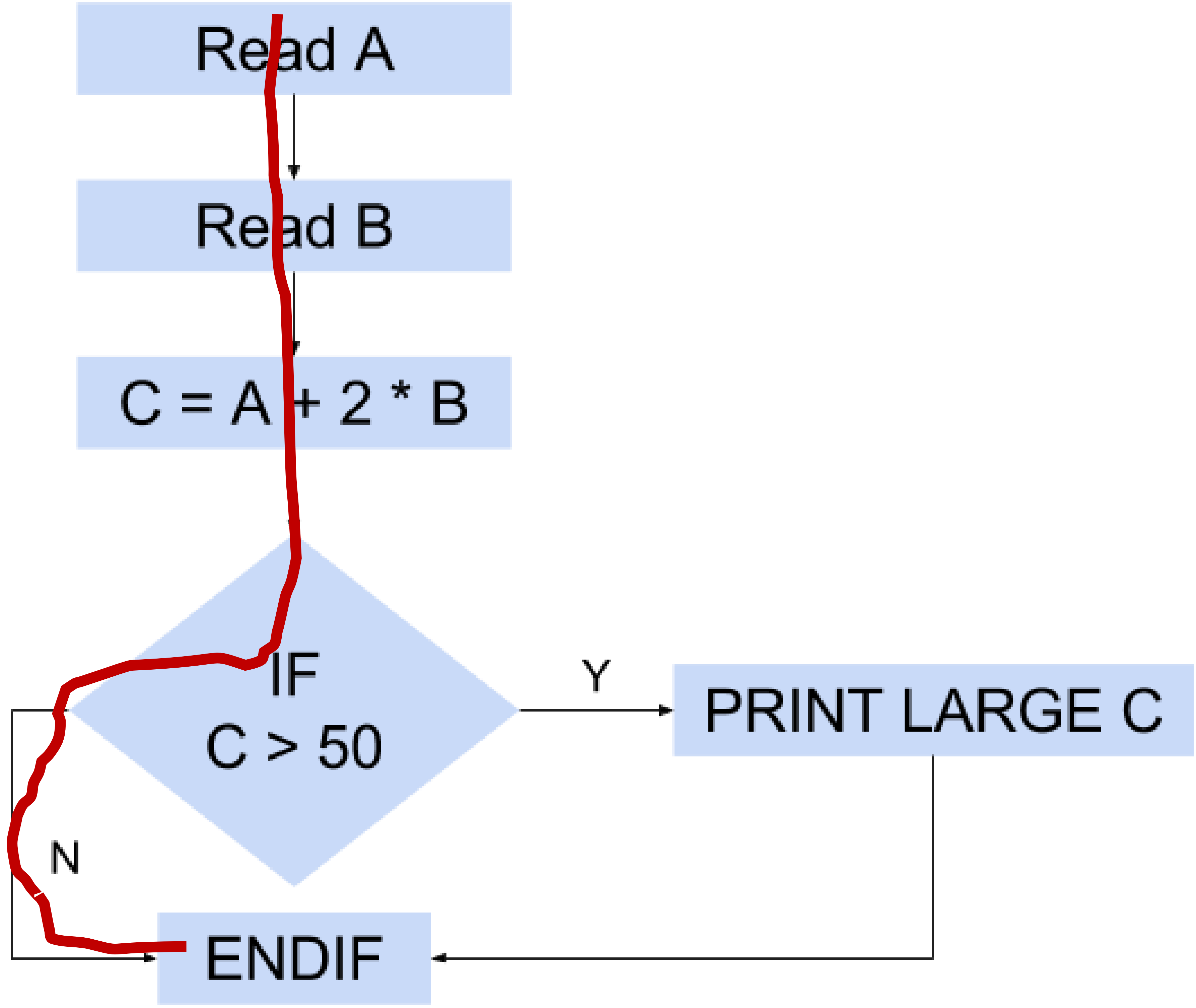
Test 1_2:

A = 0, B = 25

Test 1_3:

A = 47, B = 1

Which statements have we covered?



Question 3: Clues

Which of the following statements about the relationship between statement and decision coverage is correct?

Example II: Statement coverage

Test 1_1:

A = 2, B = 3

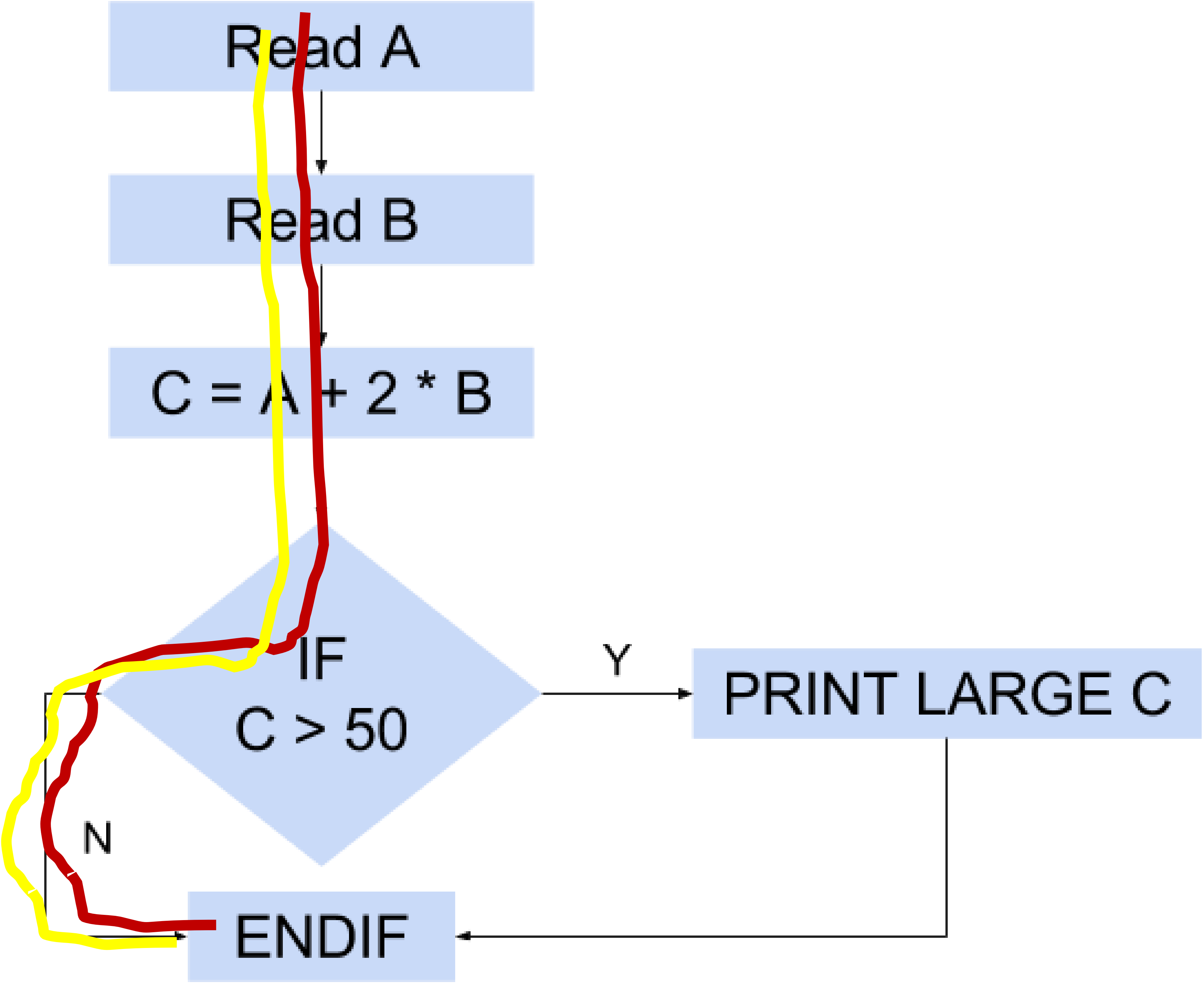
Test 1_2:

A = 0, B = 25 // C = 50

Test 1_3:

A = 47, B = 1

Which statements have we covered?



Question 3: Clues

Which of the following statements about the relationship between statement and decision coverage is correct?

Example II: Statement coverage

Test 1_1:

A = 2, B = 3

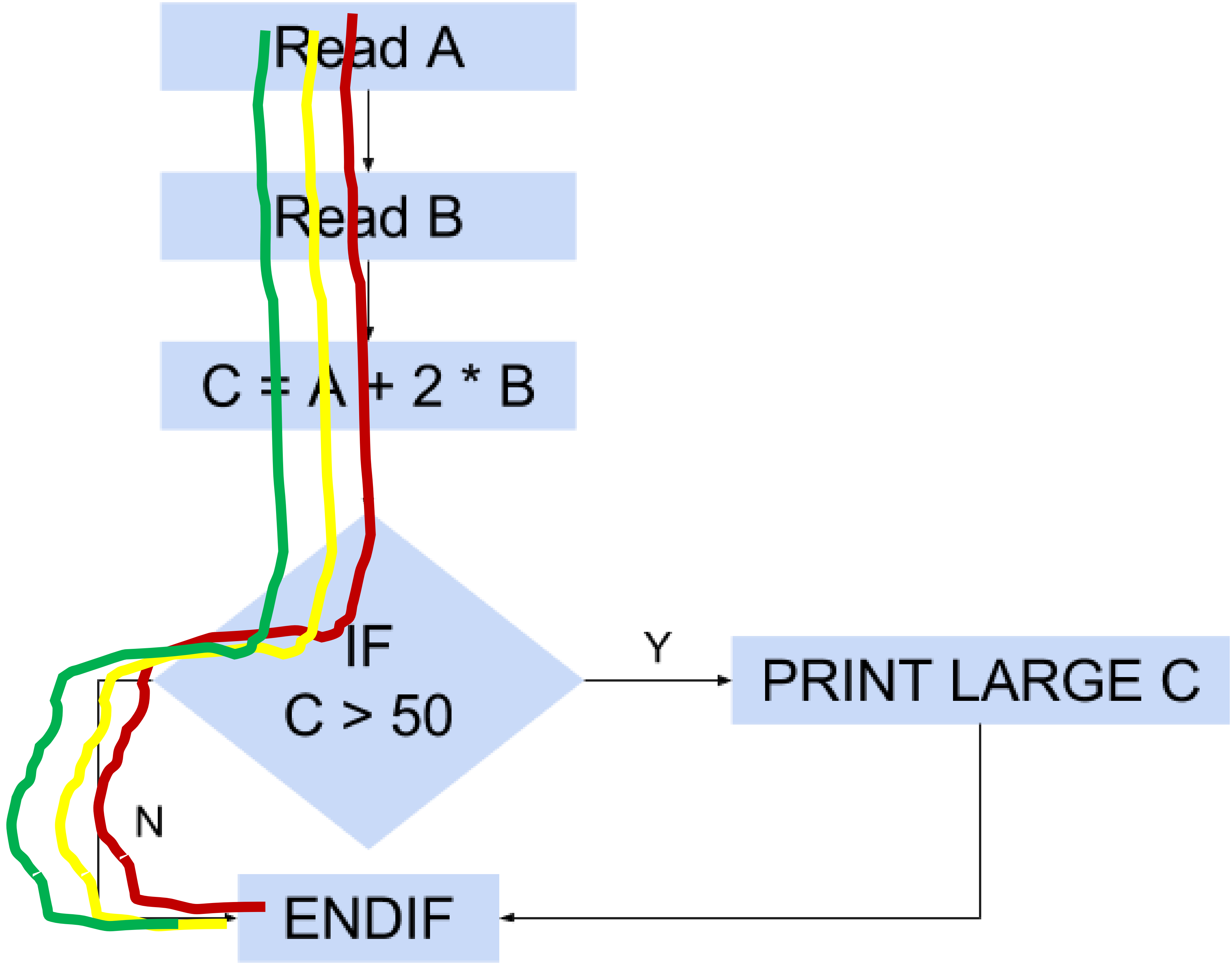
Test 1_2:

A = 0, B = 25

Test 1_3:

A = 47, B = 1 // C = 49

Which statements have we covered?



Question 3: Clues

Which of the following statements about the relationship between statement and decision coverage is correct?

Example II: Statement coverage

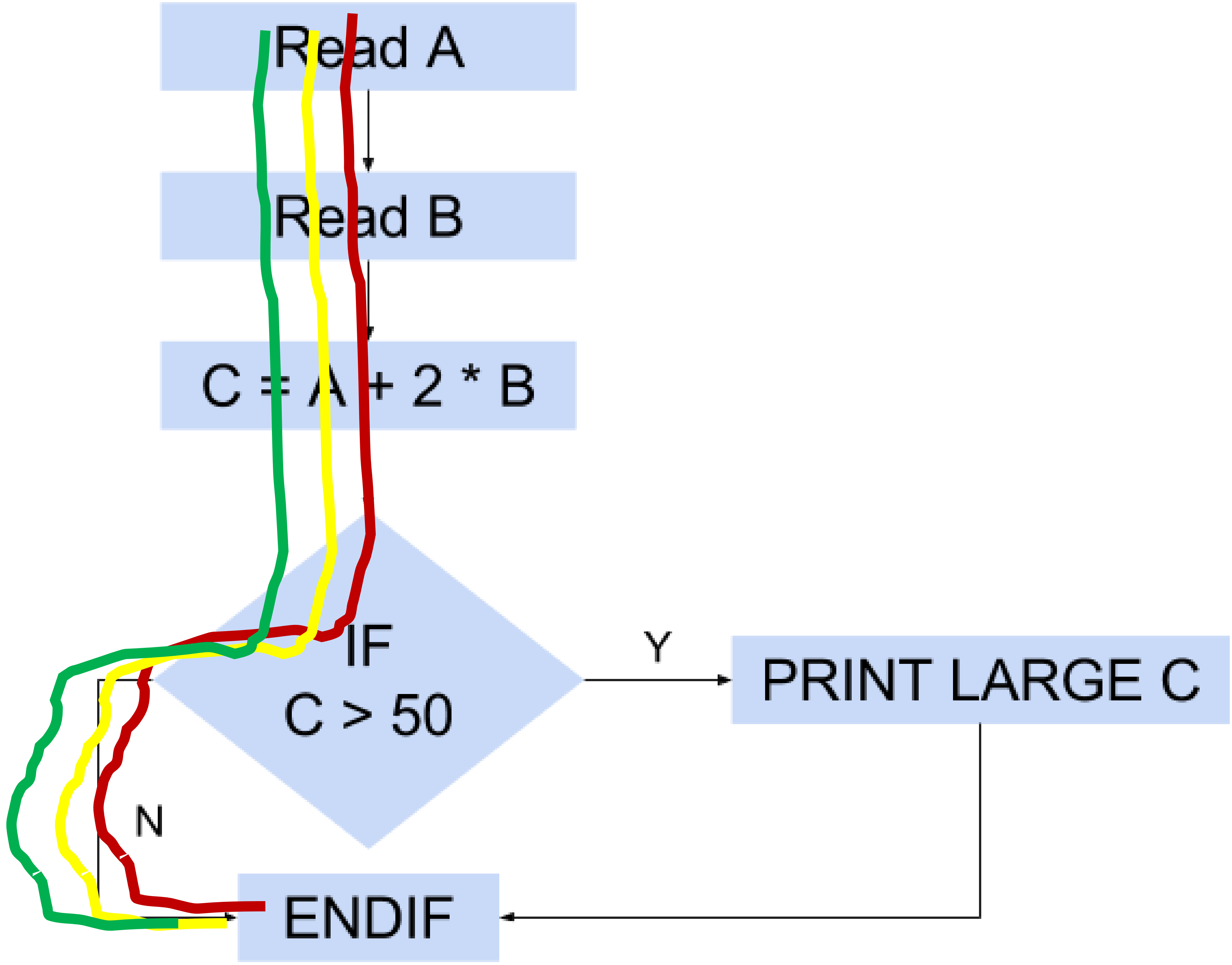
Have covered 5 out of 6 statements

Statement coverage = 83 %

Need another test to reach 100 %

Test 1_4:

A = 20, B = 25



Question 3: Clues

Which of the following statements about the relationship between statement and decision coverage is correct?

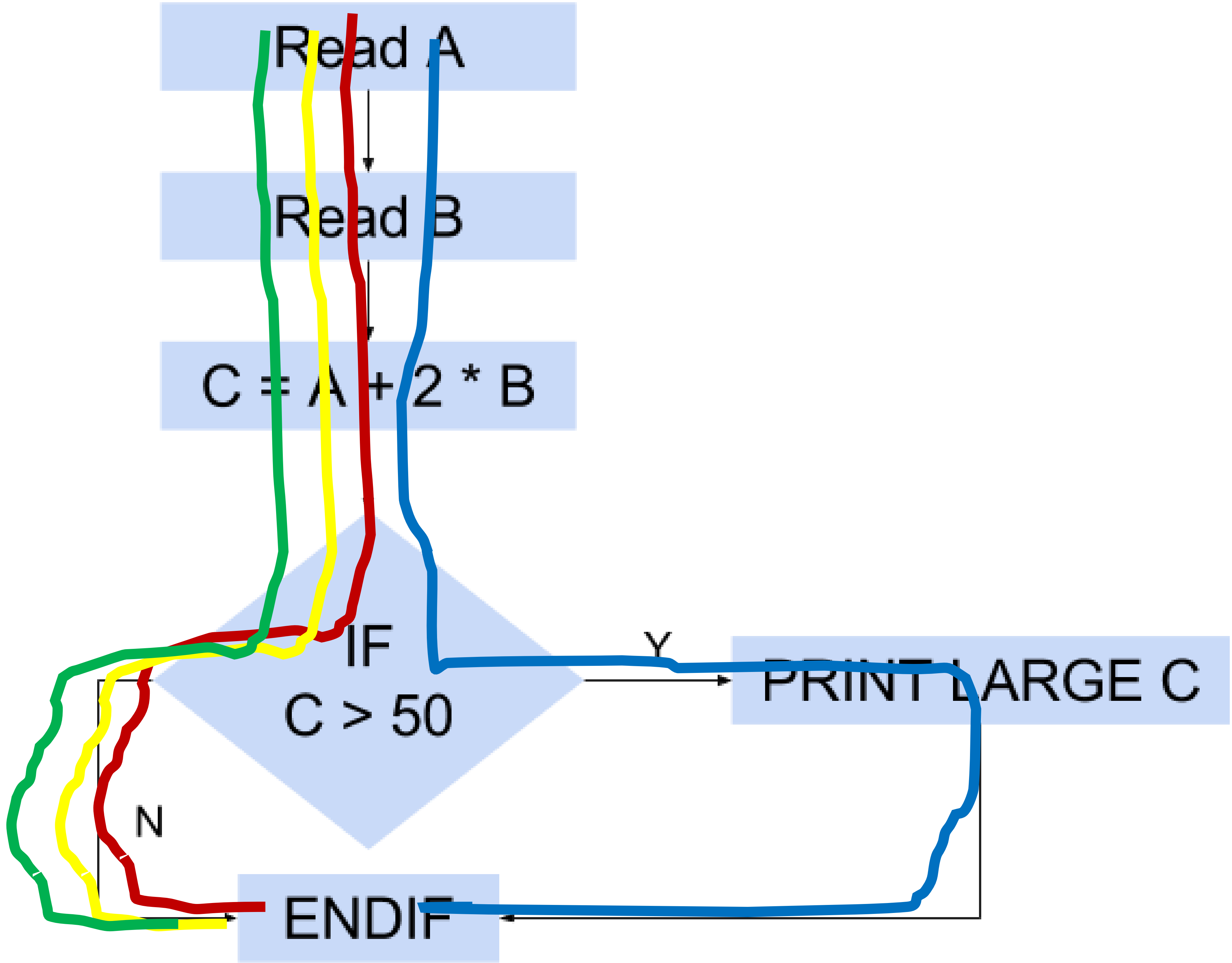
Example II: Statement coverage

Test 1_4:

A = 20, B = 25 // C = 70

Statement coverage = 100 %

In fact, only one test case needed



Question 3: Clues

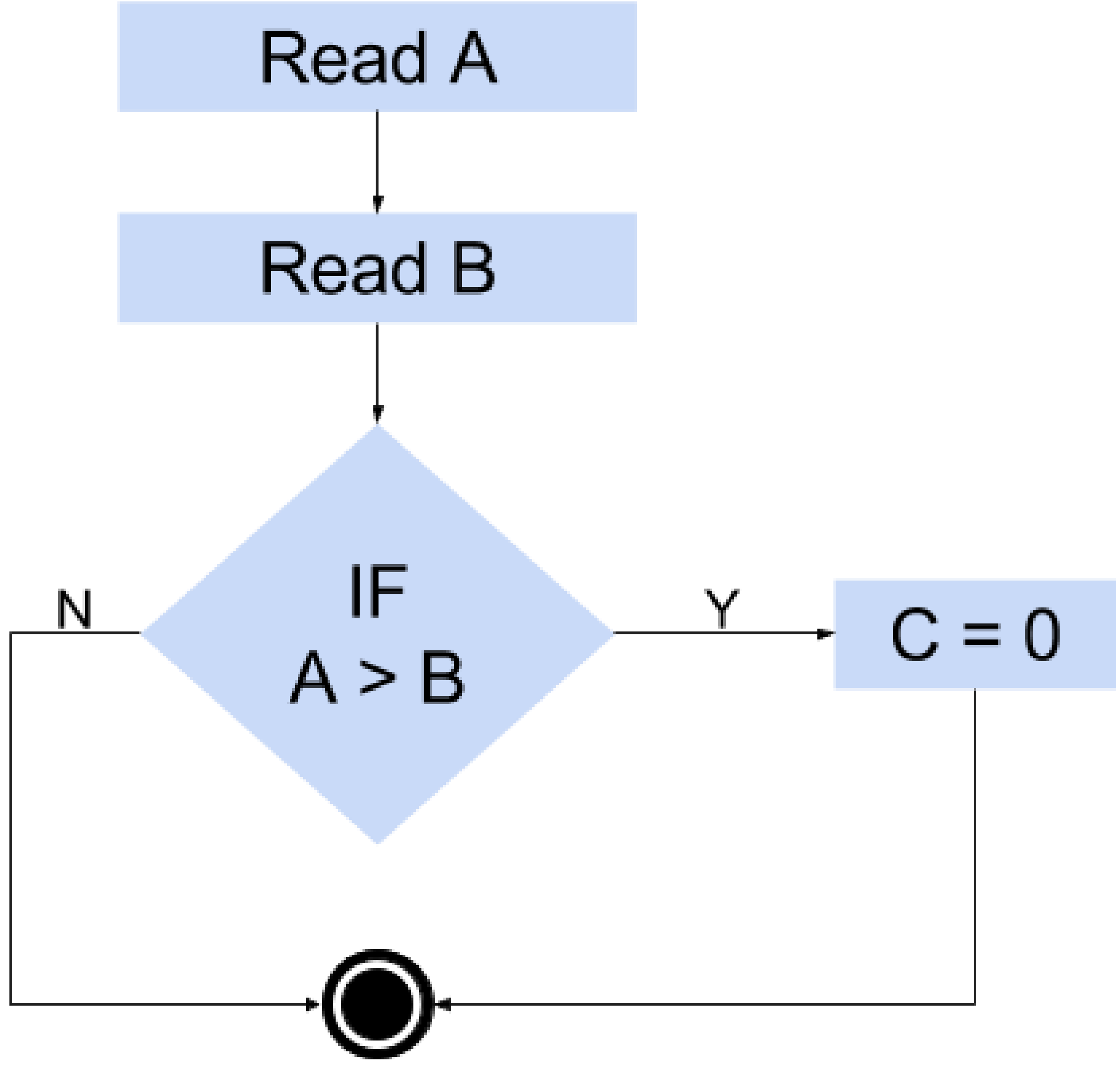
Which of the following statements about the relationship between statement and decision coverage is correct?

Decision coverage

Each decision must have both a true and false outcome

Code example (each line is a statement)

```
1   READ A
2   READ B
3   IF A > B THEN C = 0
4   ENDIF
```



To achieve 100% decision coverage: How many test cases needed?

Question 3: Clues

Which of the following statements about the relationship between statement and decision coverage is correct?

Decision coverage

One test required for 100 % statement coverage

A = 12, B = 10

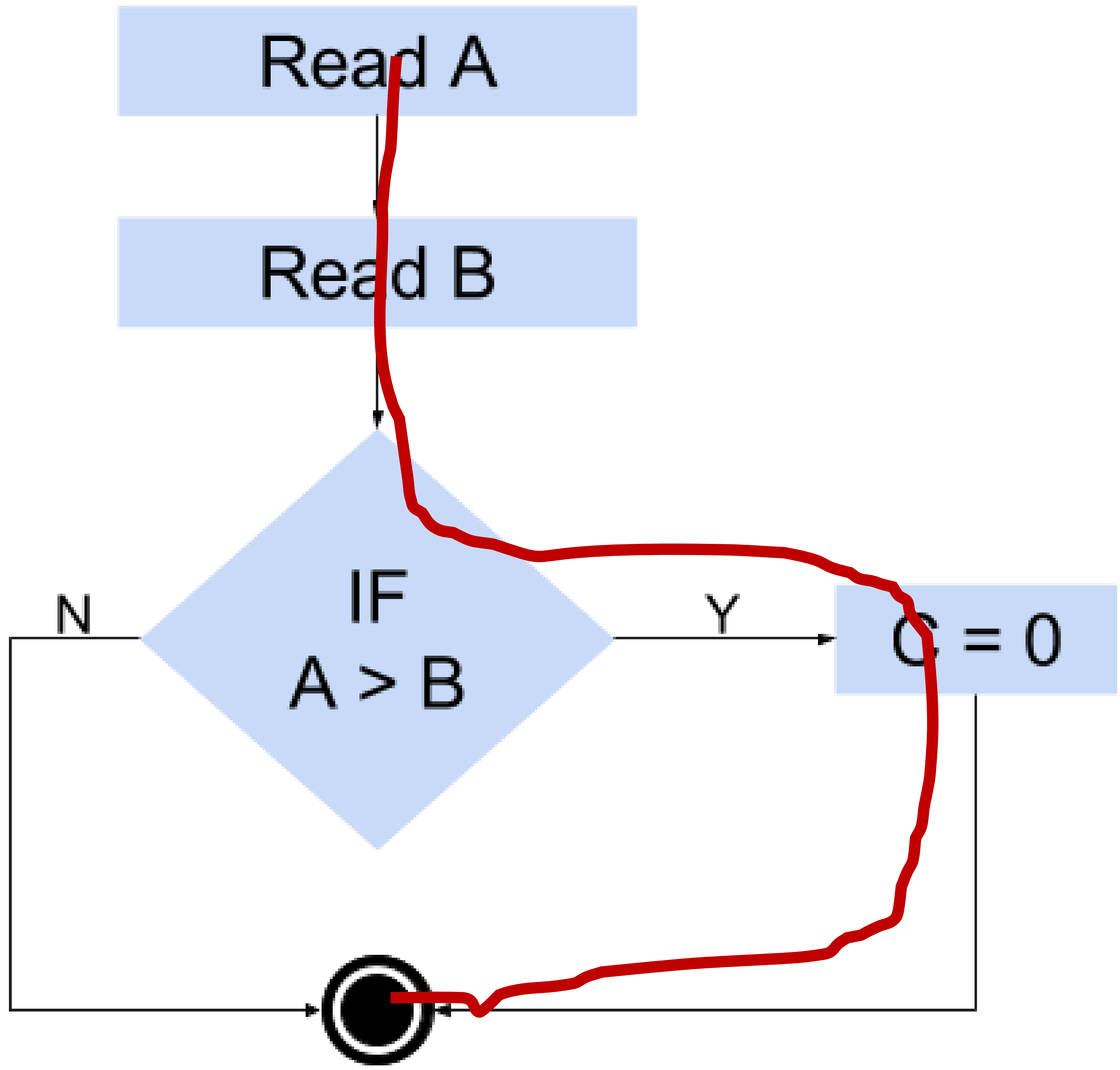
// All statements are exercised

Decision coverage requires:

Each condition must have True and False

Test case condition

A must be less than or equal to B



Question 3: Clues

Which of the following statements about the relationship between statement and decision coverage is correct?

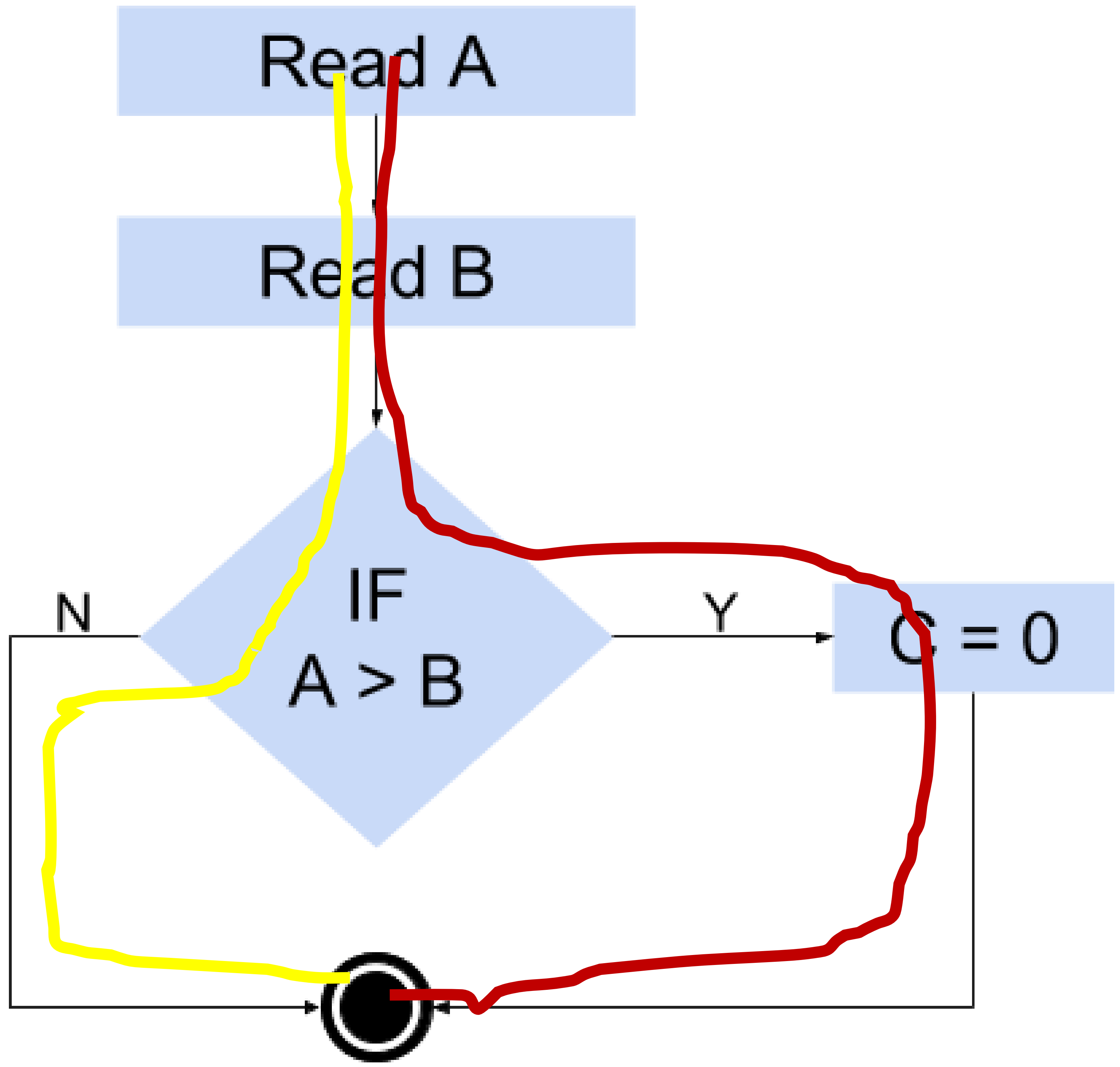
Decision coverage

Additional test case

A = 2, B = 4

// All decisions have been exercised

Have achieved 100 % decision coverage



Question 3: Clues

Which of the following statements about the relationship between statement and decision coverage is correct?

Statement and Decision coverage

$$\text{Statement coverage} = \frac{\text{Number of statements exercised}}{\text{Total number of statements}} \times 100$$

$$\text{Decision coverage} = \frac{\text{Number of decision outcomes exercised}}{\text{Total number of decision outcomes}} \times 100$$

Decision coverage is stronger than statement coverage

100 % decision coverage guarantees 100 % statement coverage

Not the other way around!

Question 4

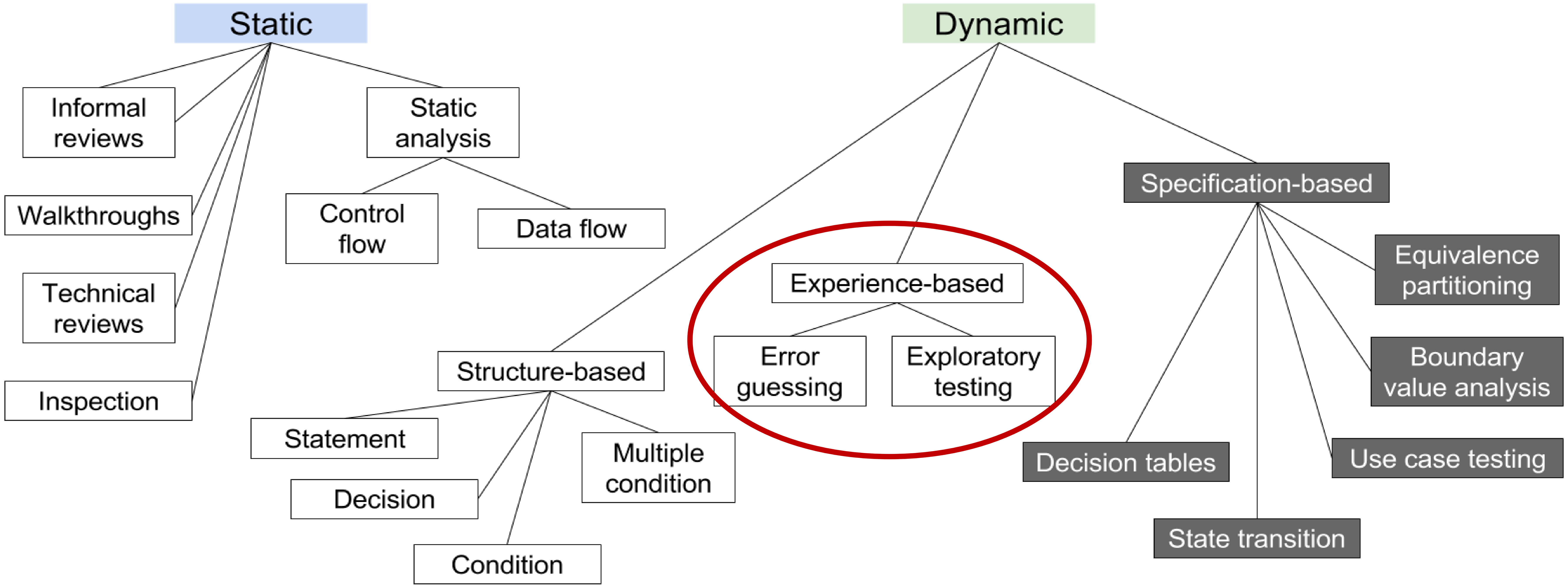
Why are error guessing and exploratory testing techniques good to do?

a. They find defects missed by specification-based and structure-based techniques
b. They don’t require any training to be as effective as formal techniques
c. They can be used more effectively when there are good specifications
d. They will ensure that all of the code or system is tested

Question 4: Clues

Why are error guessing and exploratory testing techniques good to do?

Experience-based techniques



Question 4: Clues

Why are error guessing and exploratory testing techniques good to do?

- Error-guessing and Exploratory testing
  - Experience-based techniques
- Error-guessing
  - Guess: “Where are the defects more likely to be found?”
  - Anticipate defects based on previous experience
  - Should always be used as a complement to more formal test techniques
  - Success depends on skill of the tester → Can be highly effective

Question 4: Clues

Why are error guessing and exploratory testing techniques good to do?

- Exploratory testing
  - Hands-on approach
  - Concurrent test design / execution / logging / learning
  - Testers involved in minimum planning and maximum test execution
  - Approach is useful when
    - Specification is poor / or does not exist at all
    - Time is limited
  - Can complement more formal testing → Ensure most serious defects are found

Question 5

How do experience-based techniques differ from specification-based techniques?

a. They depend on the tester’s understanding of the way the system is structured rather than on a documented record of what the system should do
b. They depend on having older testers rather than younger testers
c. They depend on a documented record of what the system should do rather than on an individual’s personal view
d. They depend on an individual’s personal view rather than on a documented record of what the system should do

Question 5: Clues

How do experience-based techniques differ from specification-based techniques?

- Experience-based techniques
  - Tests derived from skill / knowledge / experience / intuition
    - Both of technical and business people
    - Different groups yield different perspectives
  - Often based on similar applications and technologies
  - Used predominantly to complement more formal test techniques
    - Specification-based and structure-based techniques
  - Success / Effectiveness is highly dependent on the testers skill and experience

Question 6

Pair the following test design techniques with the typical problems they address:

Decision tables	Applied when the inputs or outputs can be grouped in a way that exhibits similar behaviour
Use case testing	Used to test sequences of states or sequences of transitions
State transition testing	Used when the problem can be described as an interaction between an actor and the system
Boundary value analysis	Used when the inputs and actions can be expressed as Boolean values
Equivalence partitioning	Applied when the inputs and outputs can be grouped in equivalent partitions. The technique tests the edges of each equivalence partition

Question 7

If you are flying with an economy ticket, there is a possibility that you may get upgraded to business class, especially if you hold a gold card in the airline’s frequent flyer program.

If you don’t hold a gold card, there is a possibility that you will get “bumped” off the flight if it is full and you check in late.

This is shown in the following figure. Note that each box (i.e. statement) has been numbered.

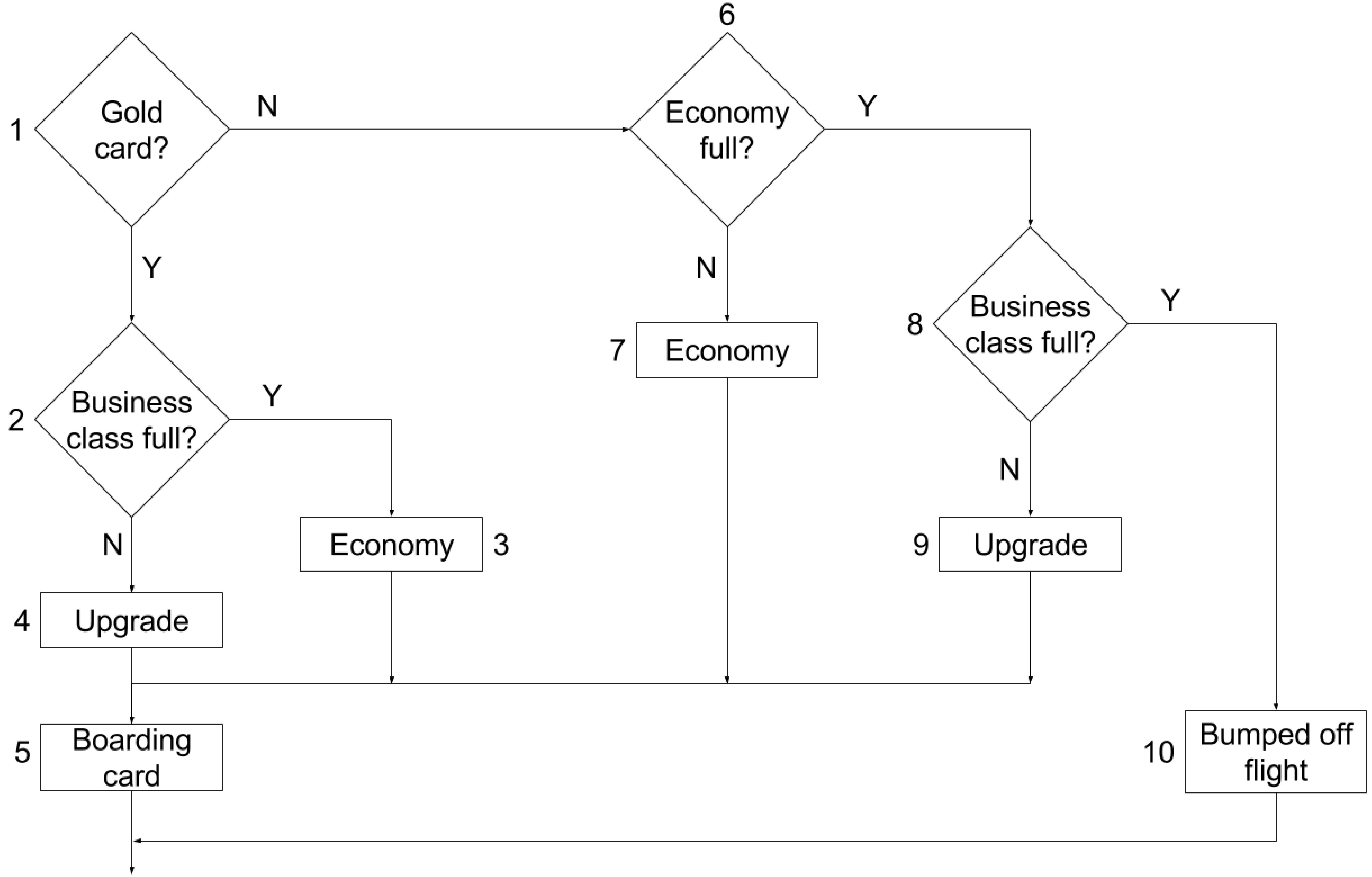
Question 7

Tests run:

Test 1
Gold card holder who gets upgraded to business class

Test 2
Non-gold card holder who stays in economy

Test 3
A person who is bumped off the flight



Question 7

What is the statement coverage of these three tests?

a. 60 %

b. 70 %

c. 80 %

d. 90 %

Question 7: Clues

What is the statement coverage of these three tests?

Calculating statement coverage

$$Statement\ coverage = \frac{Number\ of\ statements\ exercised}{Total\ number\ of\ statements} \times 100$$

After running all three tests:

Numerator: How many statements have we exercised?

Denominator: How many statements exist in total?

Multiply by a hundred to get percentage

Question 7: Clues

What is the statement coverage of these three tests?

Test 1

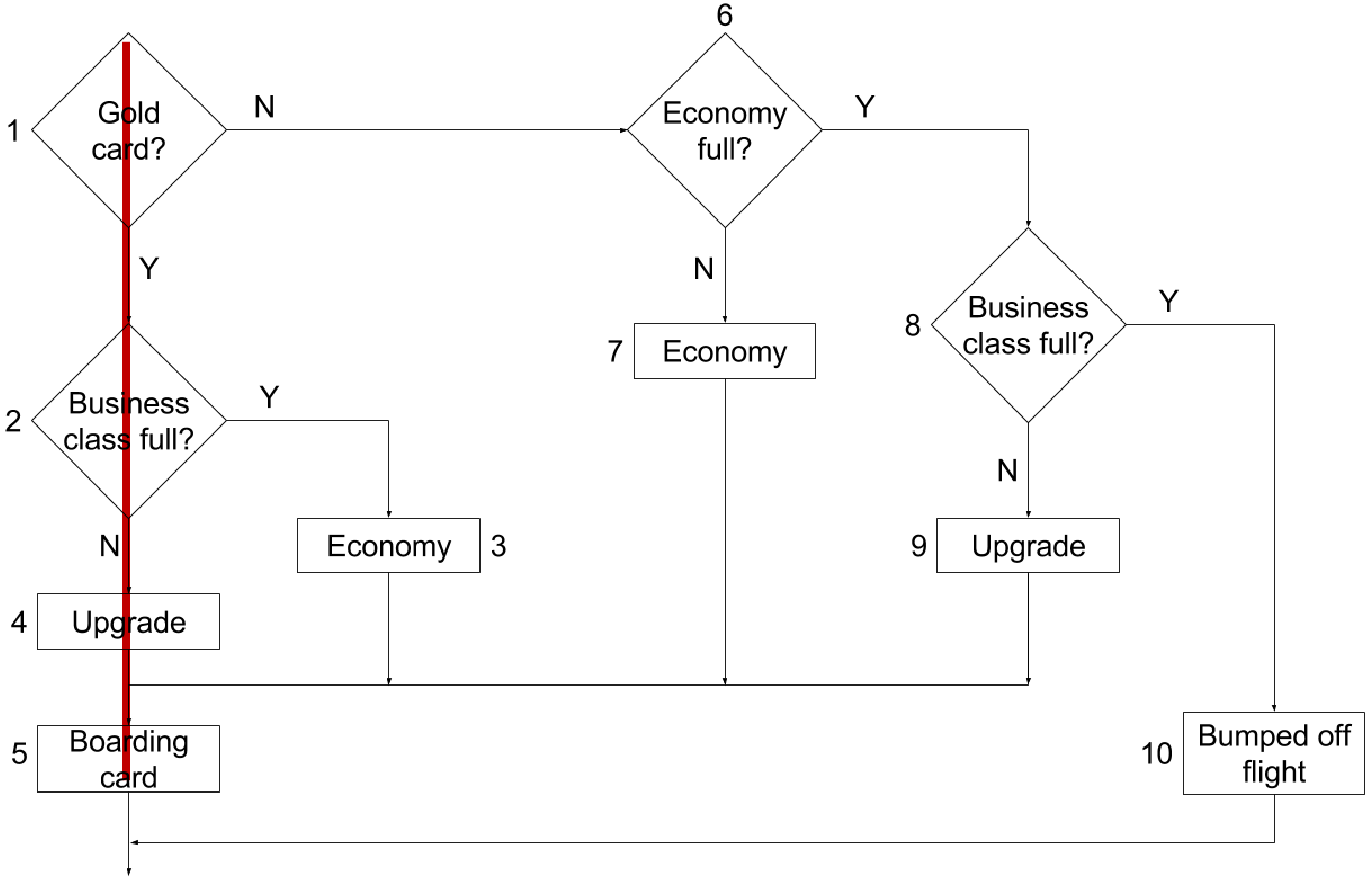
Gold card holder

Upgraded to business class

Coverage

Total statements: 10

Statements so far: 4



Question 7: Clues

What is the statement coverage of these three tests?

Test 2

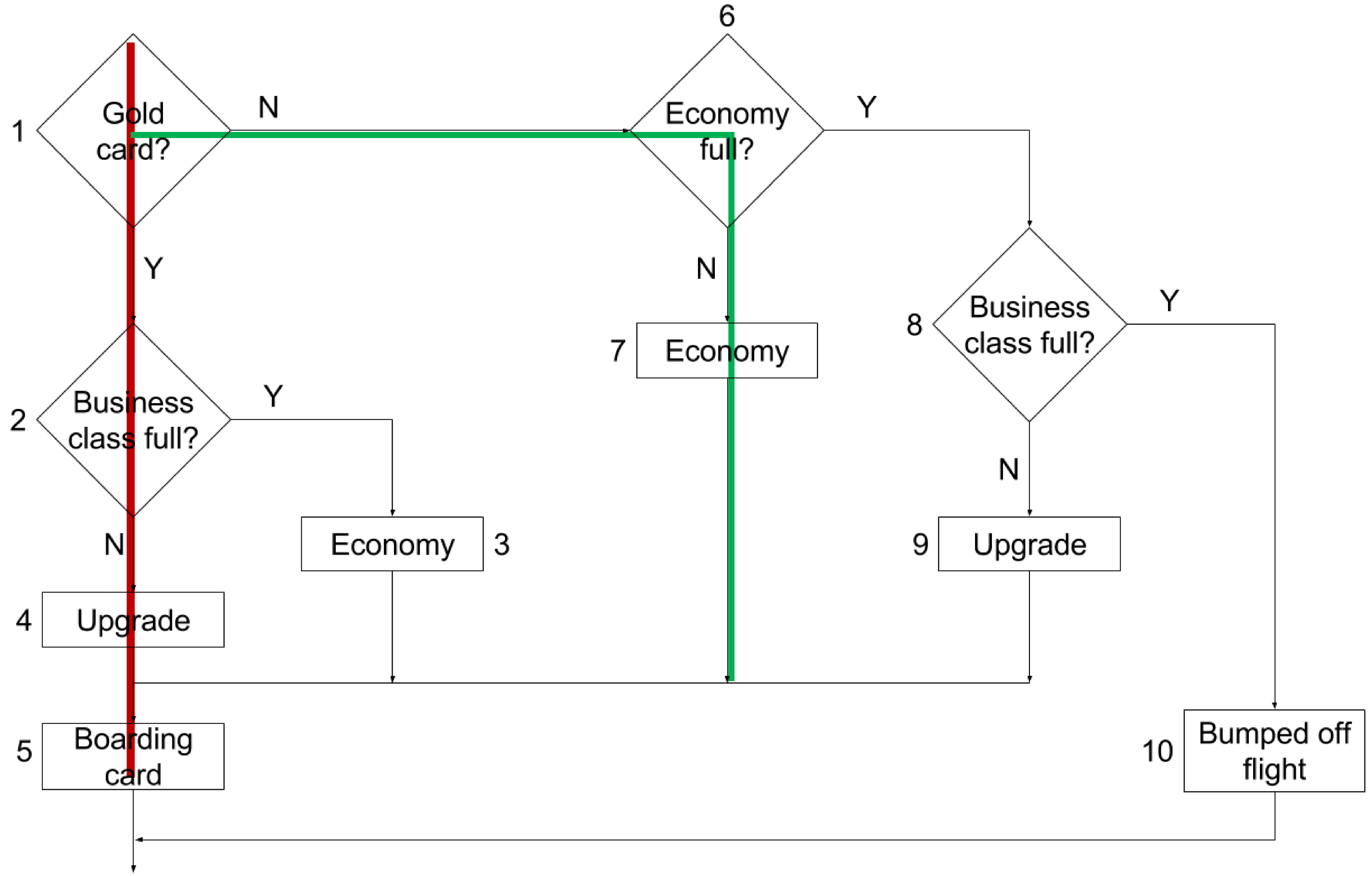
Non-gold card holder

Stays in economy

Coverage

Total statements: 10

Statements so far: 6



Question 7: Clues

What is the **statement coverage** of these three **tests**?

Test 3

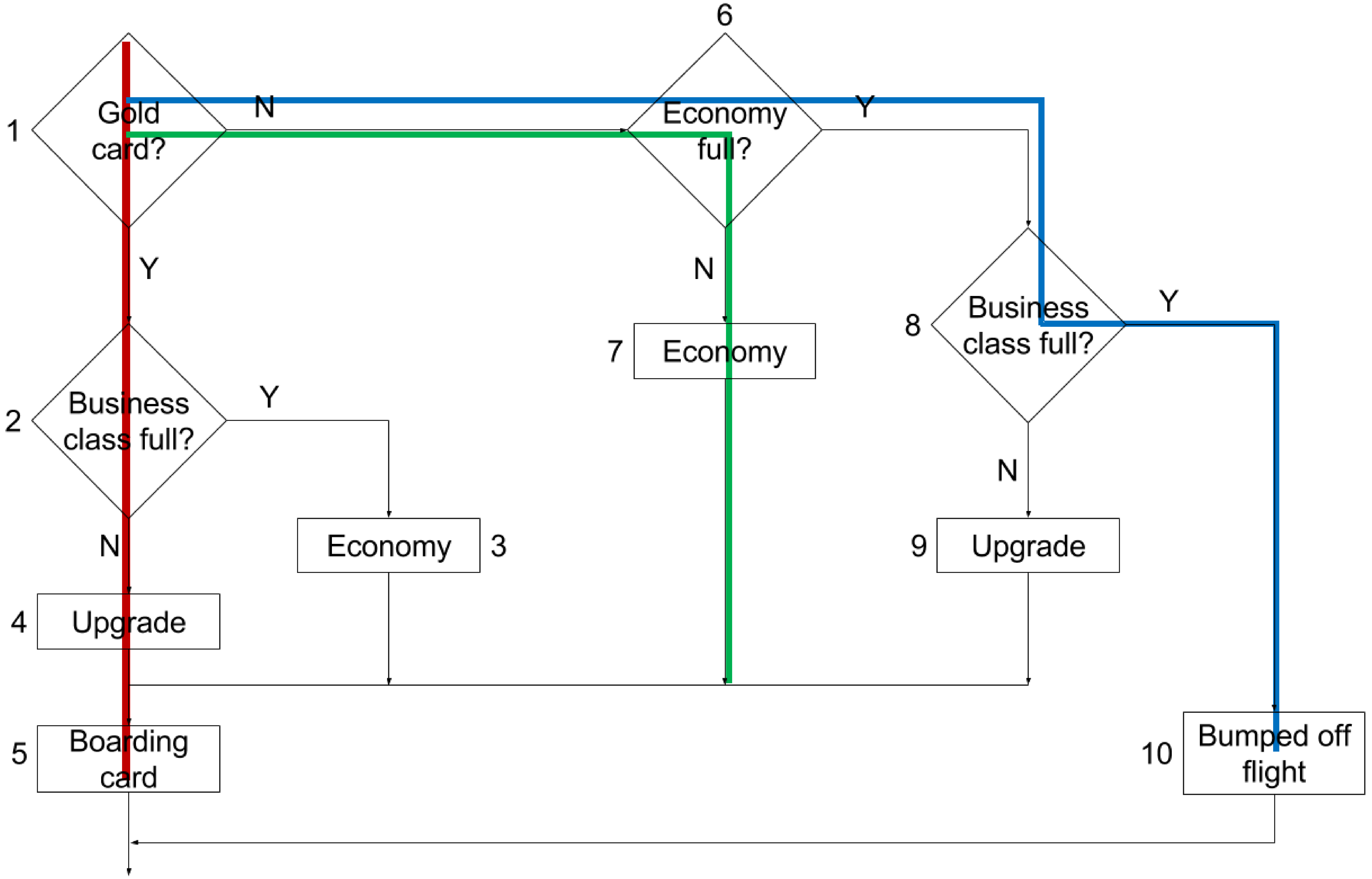
Any person

Bumped off the flight

Coverage

Total statements: 10

Statements so far: 8



Question 7: Clues

What is the statement coverage of these three tests?

Calculating statement coverage

How many statements have we exercised? 8

1. Gold card? 2. Business class full? 4. Upgrade

5. Boarding card 6. Economy full? 7. Economy

8. Business class full? 10. Bumped off flight

How many statements exist in total? 10

Have yet to exercise statements

[3. Economy] and [9. Upgrade]

Statement coverage = 80 %

Question 8

When choosing which technique to use in a given situation, which factors should be taken into account?

1. Previous experience of types of defects found in this or similar system
2. The existing knowledge of the testers
3. Regulatory standards that apply
4. The type of test executing tool that will be used
5. The documentation available
6. Previous experience in the development language

a. 2, 3, 5, and 6

b. 1, 2, 3 and 5

c. 1, 4 and 5

d. 2, 3 and 5

Question 8: Clues

When choosing which technique to use in a given situation, which factors should be taken into account?

- Which technique is best? → Wrong question
  - Each technique is good for certain instances, and less adequate for others
  - *“The best testing technique is no single testing technique”*
- Examples
  - Structure-based → Can only test what is present
    - E.g. find malicious code / Trojan horses
  - Specification-based → Can reveal if parts of specification are missing from code
  - Experience-based → Finds things missing from both specification and code

Question 8: Clues

When choosing which technique to use in a given situation, which factors should be taken into account?

- Each technique is aimed at particular types of defects
  - E.g. State-transition testing is unlikely to find boundary defects
- Use a variety of testing techniques
  - Using one technique → Ensures many defects of that particular class are found
  - However → Ensures many defects of other classes are missed
  - Using a variety of techniques
    - Ensures a variety of defects are found
    - Effective testing

Question 8: Clues

When choosing which technique to use in a given situation, which factors should be taken into account?

- Internal factors affecting choice of test techniques
  - Models used
    - If specification contains state transition diagram → State transition testing
  - Testers knowledge and experience
    - How much do testers know about the system / various techniques?
  - Likely defects
    - Each technique is good at finding particular defects
    - Knowledge about likely defects is therefore helpful

Question 8: Clues

When choosing which technique to use in a given situation, which factors should be taken into account?

- Internal factors affecting choice of test techniques
  - Test objective
    - What do we want from the test effort? → Helps us define approach
  - Documentation
    - Exists? Updated? Content → Serves to guide the test effort
  - Life cycle model
    - Sequential → Formal testing techniques
    - Iterative → Exploratory testing approach

Question 8: Clues

When choosing which technique to use in a given situation, which factors should be taken into account?

- External factors affecting choice of test techniques
  - Risk
    - The greater the risk, the greater the need for more thorough testing
  - Customer / Contractual requirements
    - Contracts may specify particular testing techniques to be used
  - Type of system
    - Influence techniques used
    - E.g. Financial application → Benefits from boundary value analysis

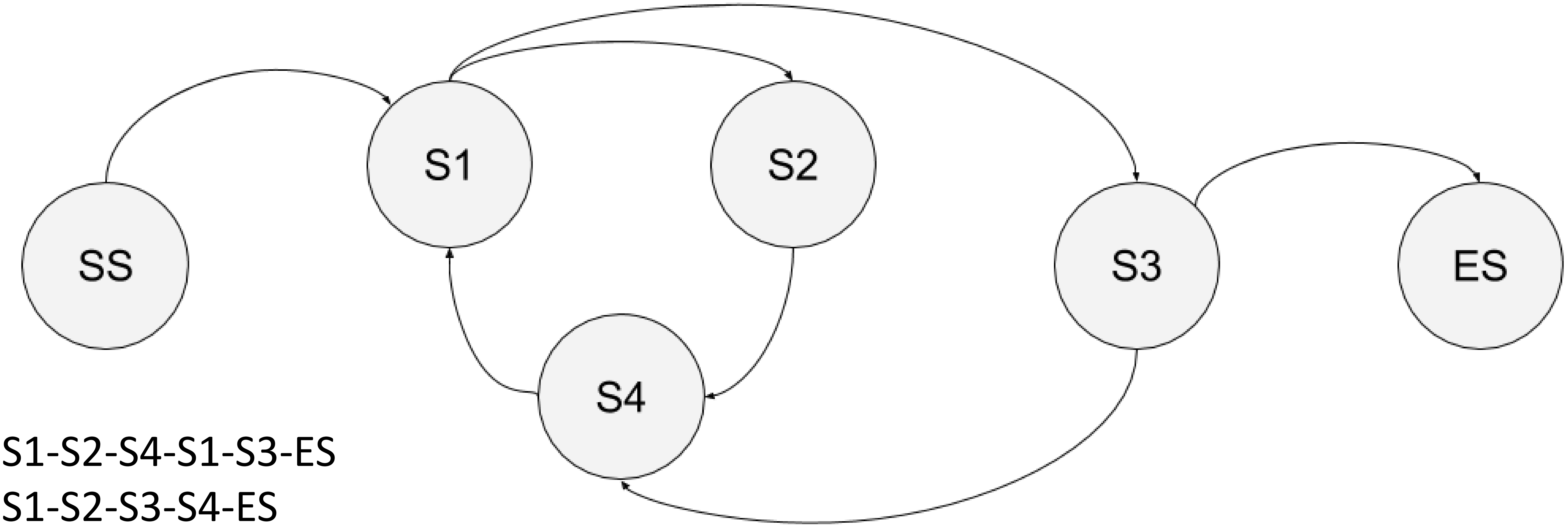
Question 8: Clues

When choosing which technique to use in a given situation, which factors should be taken into account?

- External factors affecting choice of test techniques
  - Regulatory requirements
    - Some industries have regulatory standards
    - E.g. Aircraft industry → Test effort depends on level of SW integrity required
      - Equivalence partitioning / BVA / State transition
      - Combined with statement / decision coverage
  - Time and budget
    - How much time is available? More time → More techniques

Question 9

Given the state diagram below, which test case is the minimum series of valid transitions to cover every state?

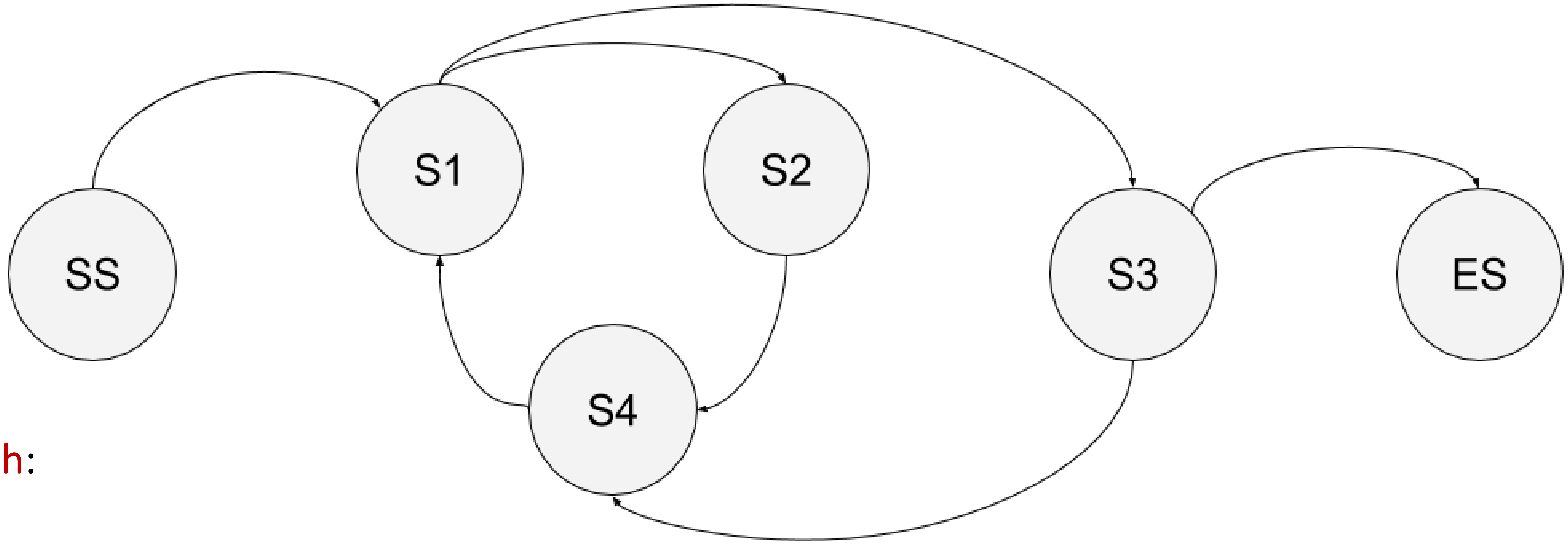


a. SS-S1-S2-S4-S1-S3-ES
b. SS-S1-S2-S3-S4-ES
c. SS-S1-S2-S4-S1-S3-S4-S1-S3-ES
d. SS-S1-S4-S2-S1-S3-ES

Question 9: Clues

Given the state diagram below, which test case is the minimum series of valid transitions to cover every state?

Want the minimum path from SS to ES, visiting each state at least once



Path:

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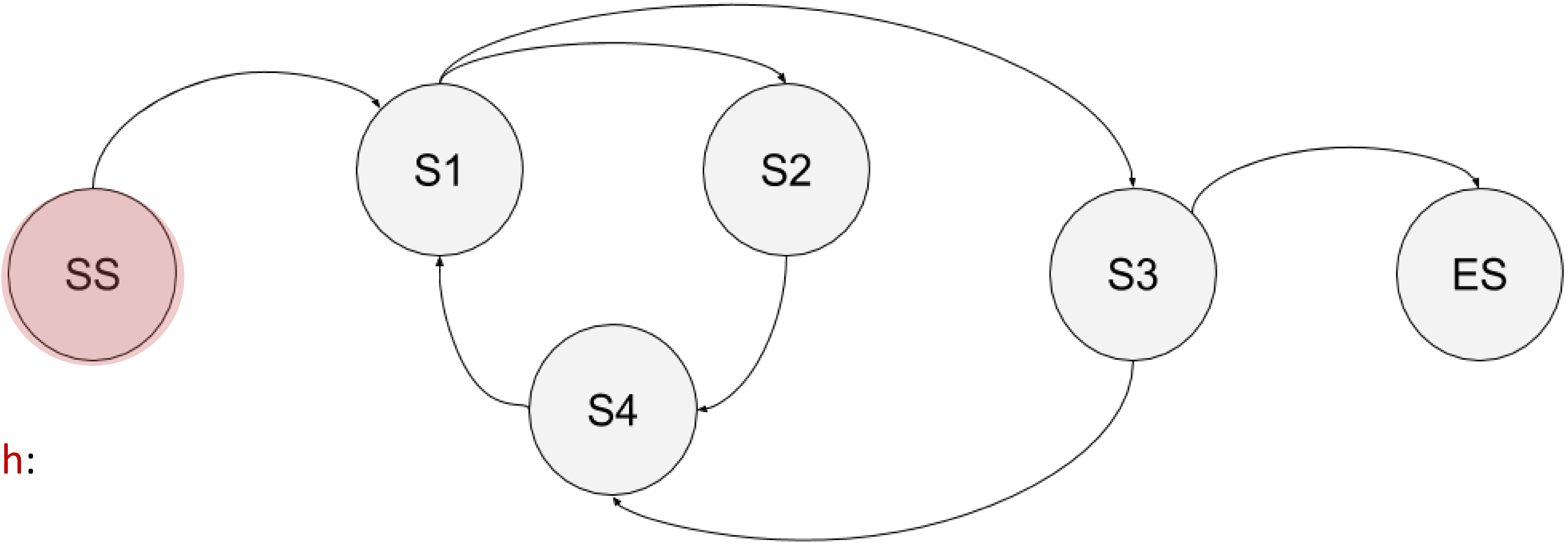

Path:
SS-

Question 9: Clues

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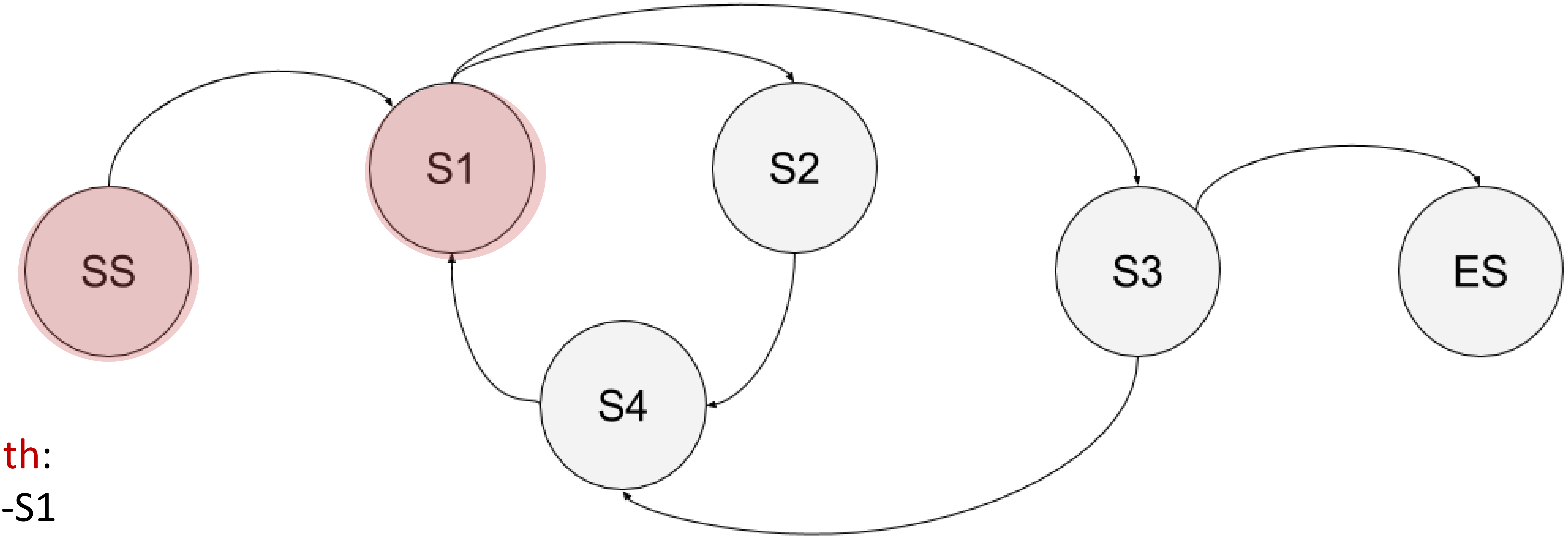
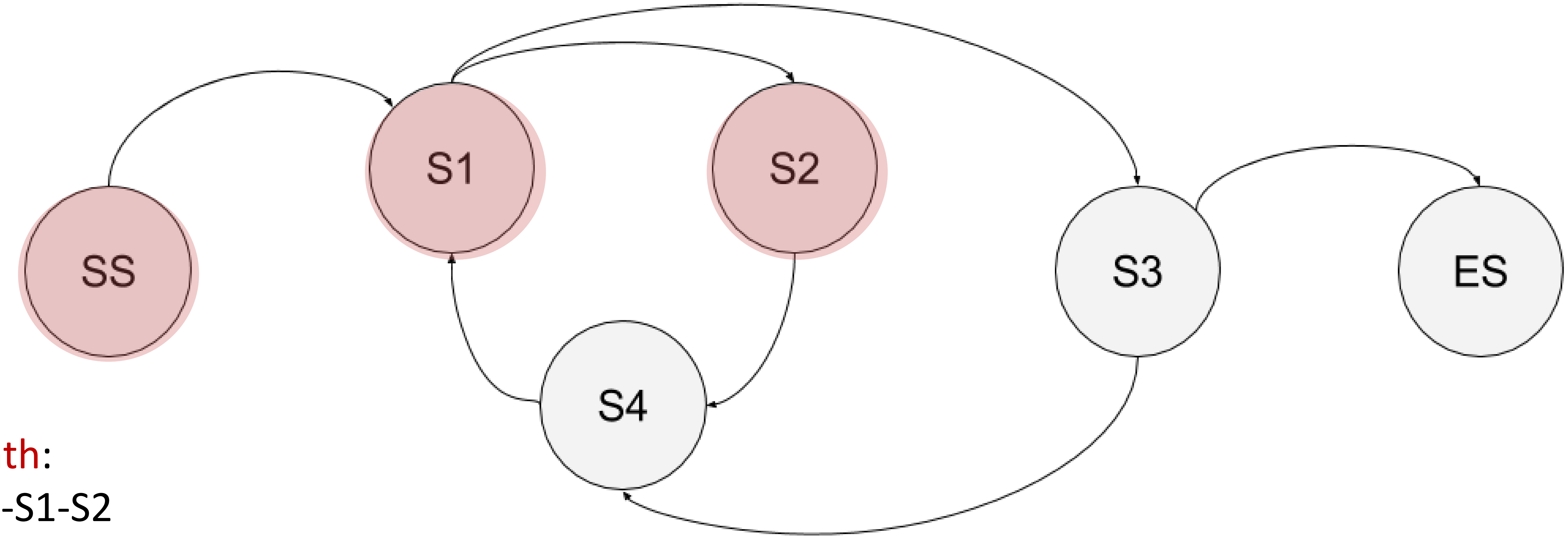


Path:
SS-S1

Question 9: Clues

Given the state diagram below, which test case is the minimum series of valid transitions to cover every state?

Want the minimum path from SS to ES, visiting each state at least once

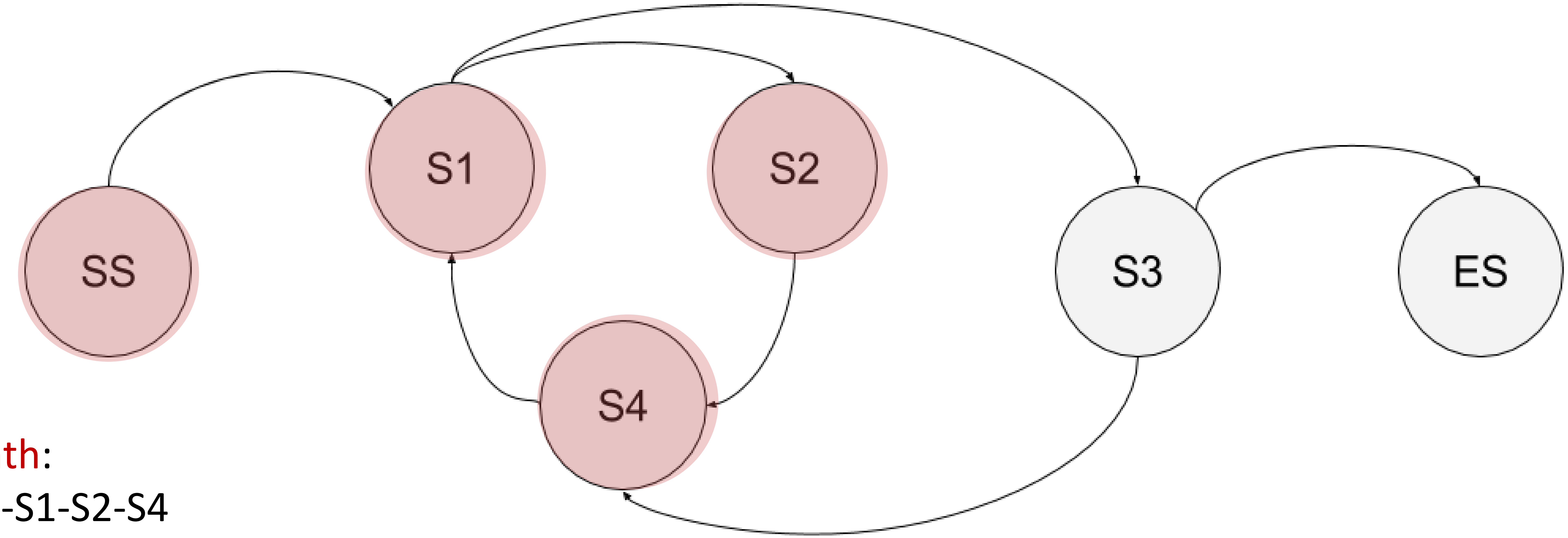


Path:
SS-S1-S2

Question 9: Clues

Given the state **diagram** below, which **test case** is the **minimum** series of **valid transitions** to **cover every** state?

Want the minimum path from SS to ES, visiting each state at least once

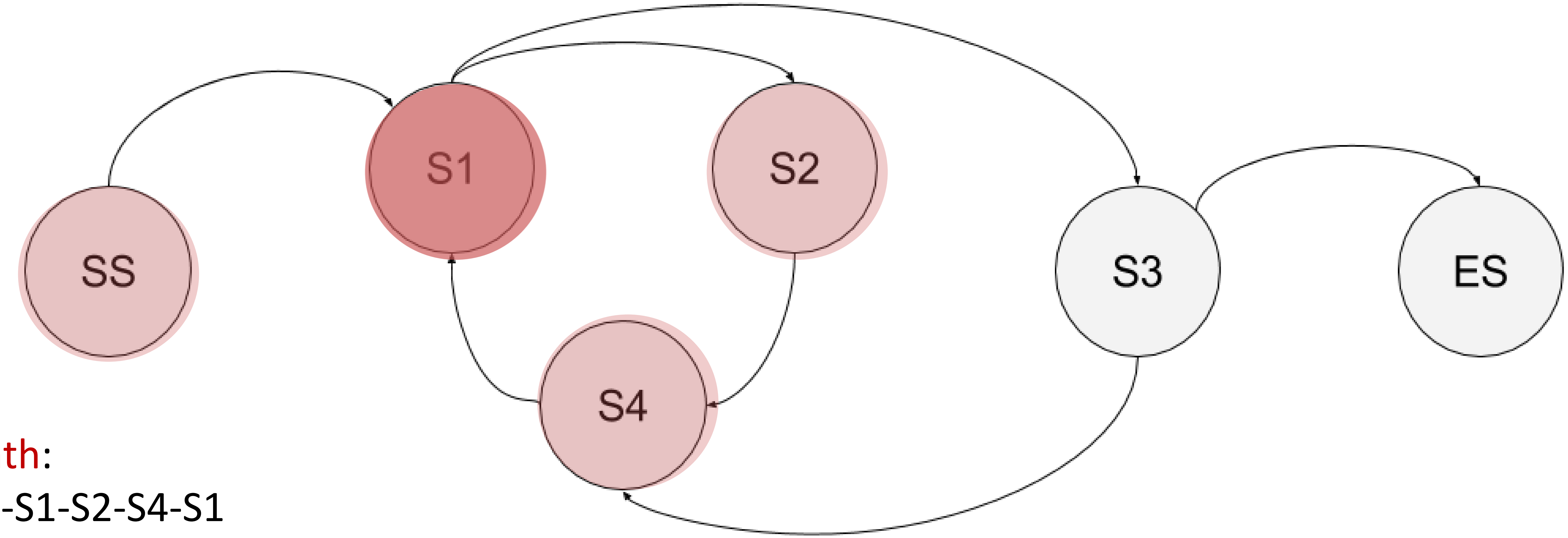


Path:
SS-S1-S2-S4

Question 9: Clues

Given the state diagram below, which test case is the minimum series of valid transitions to cover every state?

Want the minimum path from SS to ES, visiting each state at least once

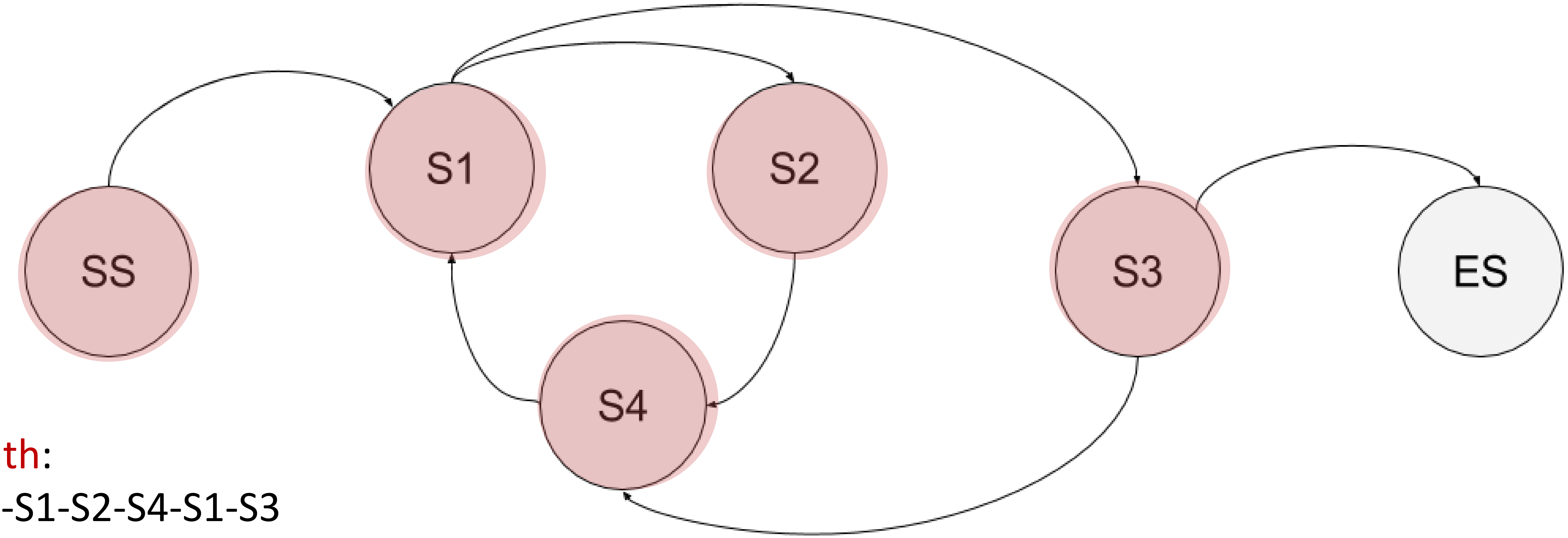


Path:
SS-S1-S2-S4-S1

Question 9: Clues

Given the state diagram below, which test case is the minimum series of valid transitions to cover every state?

Want the minimum path from SS to ES, visiting each state at least once

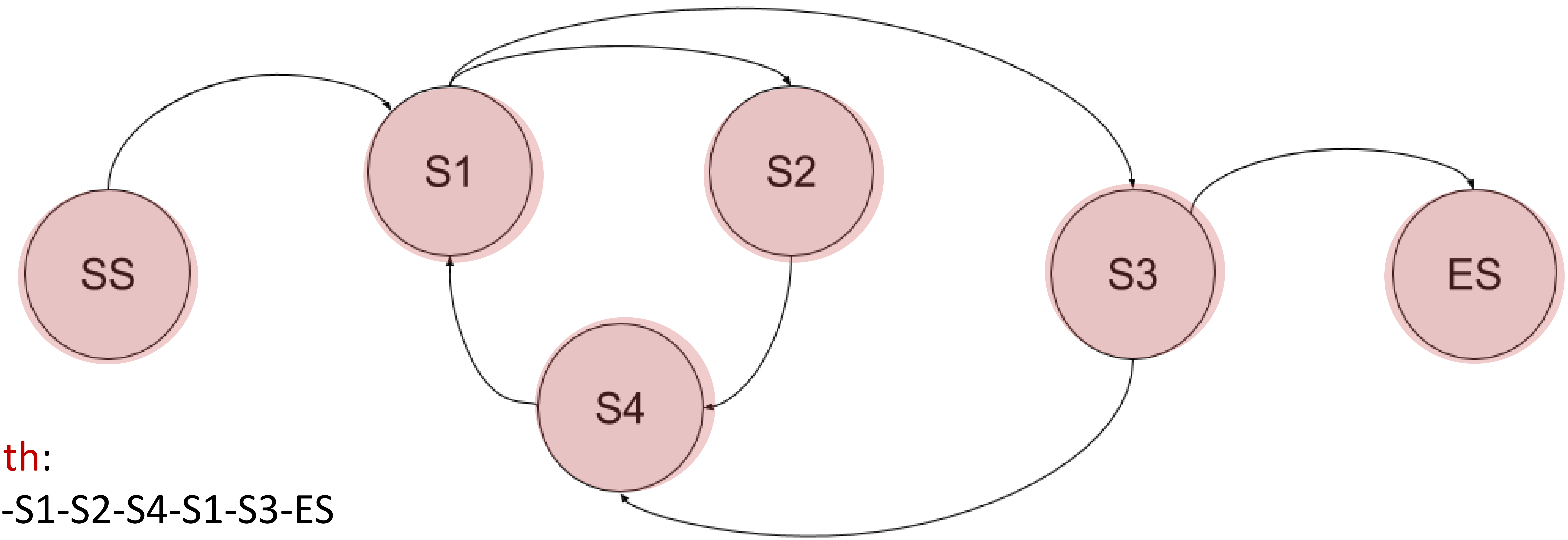


Path:
SS-S1-S2-S4-S1-S3

Question 9: Clues

Given the state **diagram** below, which **test case** is the **minimum** series of **valid transitions** to **cover every** state?

Want the minimum path from SS to ES, visiting each state at least once



Path:
SS-S1-S2-S4-S1-S3-ES

Part II: Exercises and Open-ended questions

Exercise 1: Decision Table Testing

If you hold an “over 60s” rail card, you get a 34% discount on whatever ticket you buy. If you are travelling with a child (under 16) you get a 50% discount on any ticket if you hold a family rail card, otherwise you get a 10% discount. You may only hold one type of rail card.

a. Produce a decision table showing all combinations of fare types and resulting discounts
b. Derive test cases from the decision table

Exercise 1(a): Clues

Produce a decision table showing all combinations of fare types and resulting discounts

- Fare types available based on:
  - “Over 60s” card
  - Family card
  - Travelling with a child
- Set up the decision table
  - Three different conditions → Card type
  - Each with the outcome Y / N → Holds said card type / Does not hold said card type
  - Eight different rules → Maps out combinations between inputs and outputs

Exercise 1(a): Clues

Produce a **decision table** showing all **combinations** of **fare** types and resulting **discounts**

Decision table for fare types and discounts

Each rule yields a different effect

Causes (Inputs)	R1	R2	R3	R4	R5	R6	R7	R8
Over 60s rail card?	Y	Y	Y	Y	N	N	N	N
Family rail card?	Y	Y	N	N	Y	Y	N	N
Child also travelling?	Y	N	Y	N	Y	N	Y	N
Effects (Outputs)								
Discount (%)								

Exercise 1(a): Clues

Produce a **decision table** showing all **combinations** of **fare** types and resulting **discounts**

Decision table

R8: No rail cards and no children travelling

Causes (Inputs)	R1	R2	R3	R4	R5	R6	R7	**R8**
Over 60s rail card?	Y	Y	Y	Y	N	N	N	**N**
Family rail card?	Y	Y	N	N	Y	Y	N	**N**
Child also travelling?	Y	N	Y	N	Y	N	Y	**N**
Effects (Outputs)								
Discount (%)								**0%**

Exercise 1(a): Clues

Produce a **decision table** showing all **combinations** of **fare** types and resulting **discounts**

Decision table

R7: No rail cards, but travelling with children

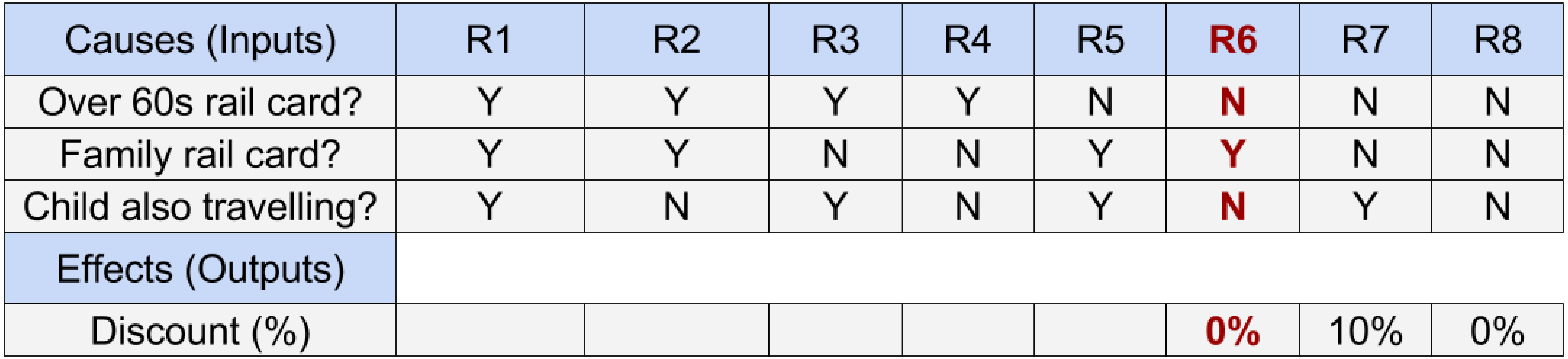
Causes (Inputs)	R1	R2	R3	R4	R5	R6	**R7**	R8
Over 60s rail card?	Y	Y	Y	Y	N	N	**N**	N
Family rail card?	Y	Y	N	N	Y	Y	**N**	N
Child also travelling?	Y	N	Y	N	Y	N	**Y**	N
Effects (Outputs)								
Discount (%)							**10%**	0%

Exercise 1(a): Clues

Produce a **decision table** showing all **combinations** of **fare** types and resulting **discounts**

Decision table

R6: No “Over 60s” card, with family card, but no children travelling



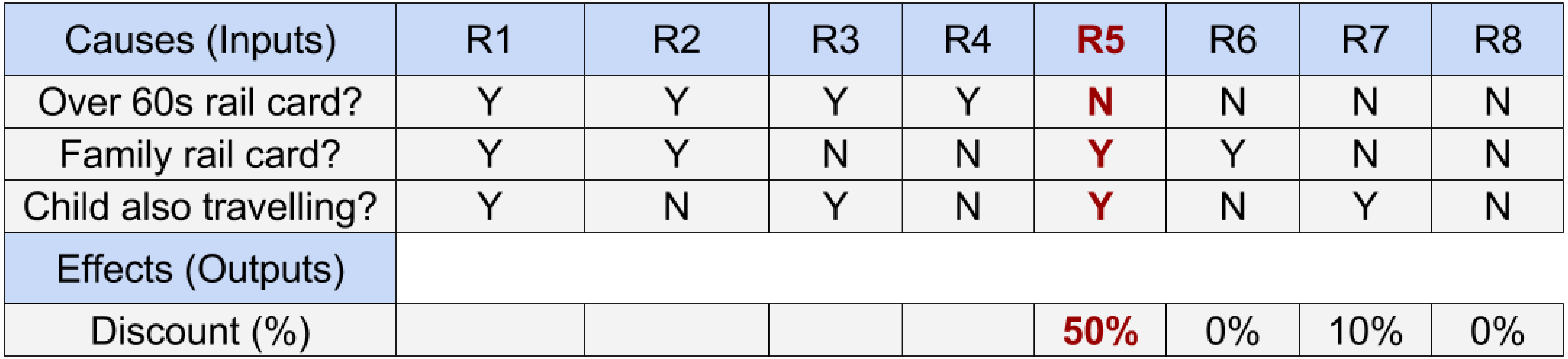
Causes (Inputs)	R1	R2	R3	R4	R5	**R6**	R7	R8
Over 60s rail card?	Y	Y	Y	Y	N	**N**	N	N
Family rail card?	Y	Y	N	N	Y	**Y**	N	N
Child also travelling?	Y	N	Y	N	Y	**N**	Y	N
Effects (Outputs)								
Discount (%)						**0%**	10%	0%

Exercise 1(a): Clues

Produce a **decision table** showing all **combinations** of **fare** types and resulting **discounts**

Decision table

R5: No “Over 60s” card, with family card, and with children travelling



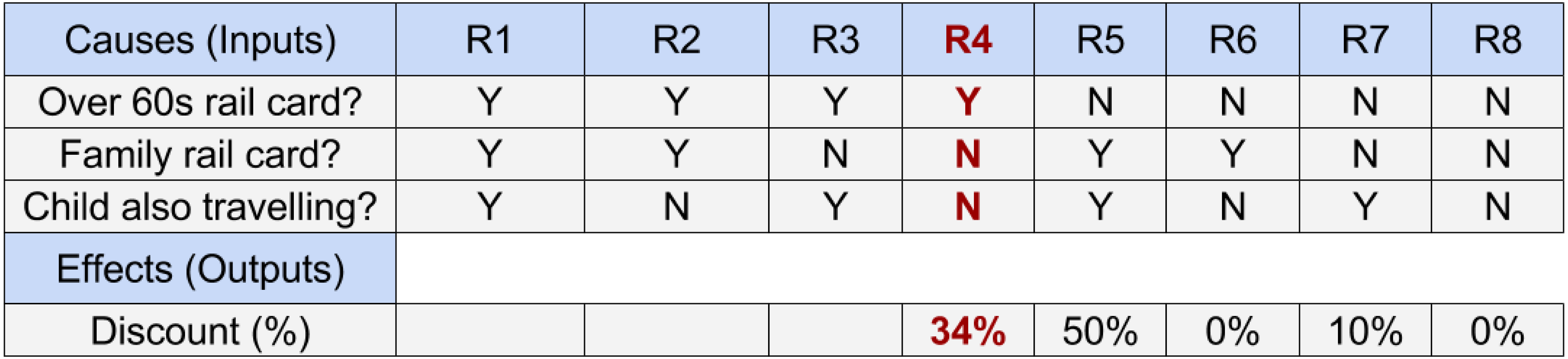
Causes (Inputs)	R1	R2	R3	R4	**R5**	R6	R7	R8
Over 60s rail card?	Y	Y	Y	Y	**N**	N	N	N
Family rail card?	Y	Y	N	N	**Y**	Y	N	N
Child also travelling?	Y	N	Y	N	**Y**	N	Y	N
Effects (Outputs)								
Discount (%)					**50%**	0%	10%	0%

Exercise 1(a): Clues

Produce a **decision table** showing all **combinations** of **fare** types and resulting **discounts**

Decision table

R4: Holds “Over 60s” card, no family card, and no children travelling



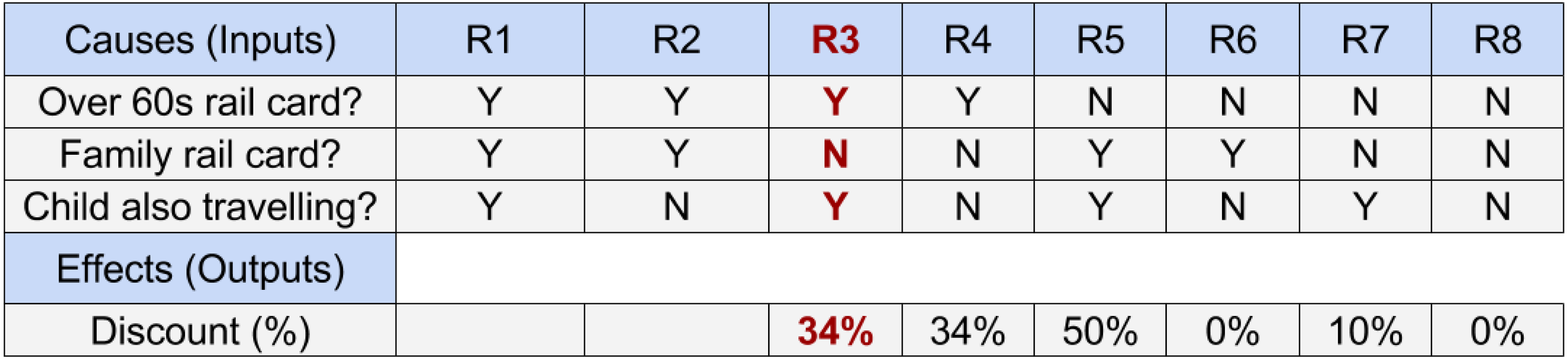
Causes (Inputs)	R1	R2	R3	**R4**	R5	R6	R7	R8
Over 60s rail card?	Y	Y	Y	**Y**	N	N	N	N
Family rail card?	Y	Y	N	**N**	Y	Y	N	N
Child also travelling?	Y	N	Y	**N**	Y	N	Y	N
Effects (Outputs)								
Discount (%)				**34%**	50%	0%	10%	0%

Exercise 1(a): Clues

Produce a **decision table** showing all **combinations** of **fare** types and resulting **discounts**

Decision table

R3: Holds “Over 60s” card, no family card, but with children travelling



Causes (Inputs)	R1	R2	**R3**	R4	R5	R6	R7	R8
Over 60s rail card?	Y	Y	**Y**	Y	N	N	N	N
Family rail card?	Y	Y	**N**	N	Y	Y	N	N
Child also travelling?	Y	N	**Y**	N	Y	N	Y	N
Effects (Outputs)								
Discount (%)			**34%**	34%	50%	0%	10%	0%

Exercise 1(a): Clues

Produce a **decision table** showing all **combinations** of **fare** types and resulting **discounts**

Decision table

R2: Holds “Over 60s” card, has family card, but no children travelling

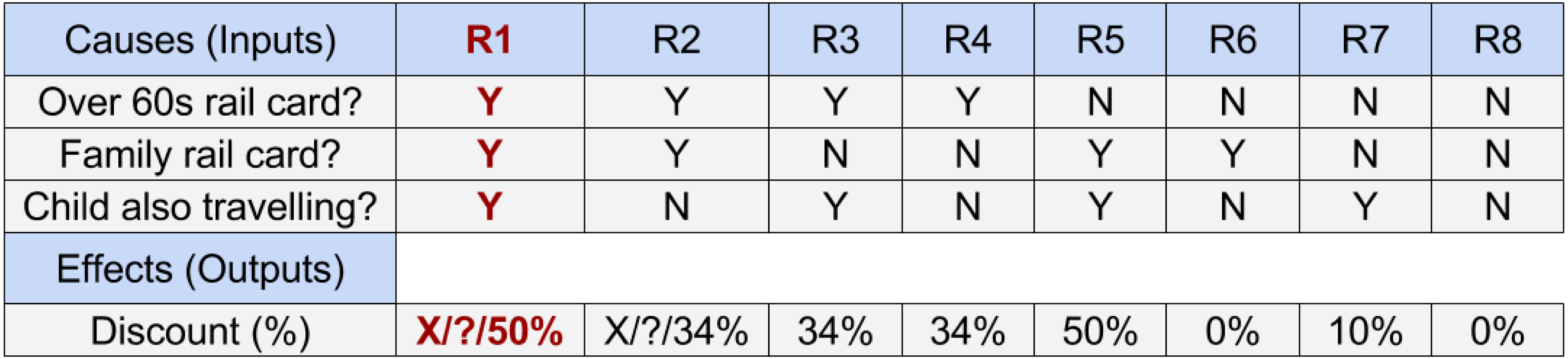
Causes (Inputs)	R1	**R2**	R3	R4	R5	R6	R7	R8
Over 60s rail card?	Y	**Y**	Y	Y	N	N	N	N
Family rail card?	Y	**Y**	N	N	Y	Y	N	N
Child also travelling?	Y	**N**	Y	N	Y	N	Y	N
Effects (Outputs)								
Discount (%)		**X/?/34%**	34%	34%	50%	0%	10%	0%

Exercise 1(a): Clues

Produce a **decision table** showing all **combinations** of **fare** types and resulting **discounts**

Decision table

R1: Holds “Over 60s” card, has family card, with children travelling



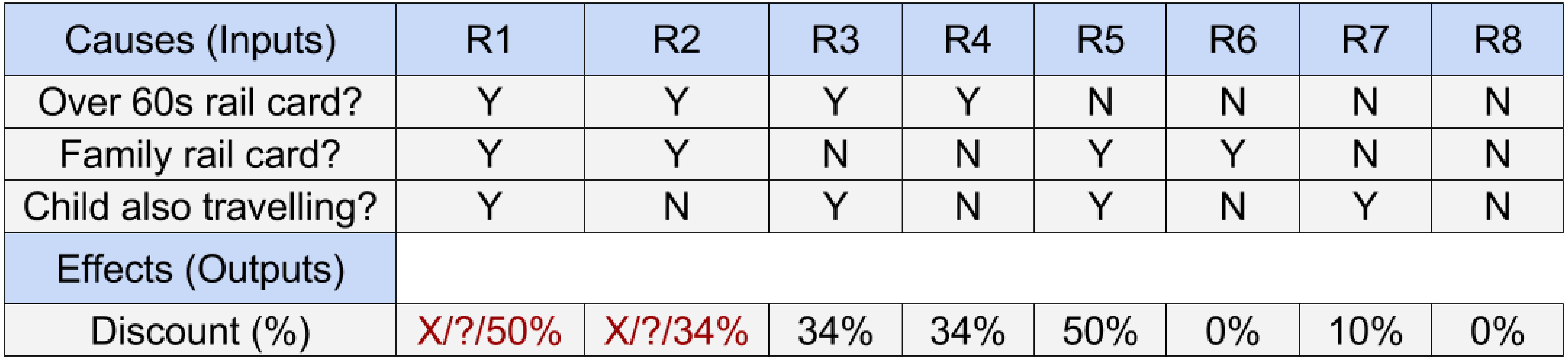
Causes (Inputs)	**R1**	R2	R3	R4	R5	R6	R7	R8
Over 60s rail card?	**Y**	Y	Y	Y	N	N	N	N
Family rail card?	**Y**	Y	N	N	Y	Y	N	N
Child also travelling?	**Y**	N	Y	N	Y	N	Y	N
Effects (Outputs)								
Discount (%)	**X/?/50%**	X/?/34%	34%	34%	50%	0%	10%	0%

Exercise 1(a): Clues

Produce a **decision table** showing all **combinations** of **fare** types and resulting **discounts**

Decision table

Final result → What is the output for R1 and R2?



Causes (Inputs)	R1	R2	R3	R4	R5	R6	R7	R8
Over 60s rail card?	Y	Y	Y	Y	N	N	N	N
Family rail card?	Y	Y	N	N	Y	Y	N	N
Child also travelling?	Y	N	Y	N	Y	N	Y	N
Effects (Outputs)								
Discount (%)	X/?/50%	X/?/34%	34%	34%	50%	0%	10%	0%

Exercise 1(a): Clues

Produce a decision table showing all combinations of fare types and resulting discounts

What is the output for R1 and R2?

X → Not possible to hold more than one rail card

? → Specification does not tell us what happens for said cases

If someone holds two cards → Not likely to admit that

R1: Claim 50% discount with family rail card and travelling with children

R2: Claim 34 % discount with "Over 60s" card and no children

Notation shows we do not know the expected outcome for R1 and R2

Have revealed ambiguities in the specification

Exercise 1(a): Clues

Produce a decision table showing all combinations of fare types and resulting discounts

Further simplifications

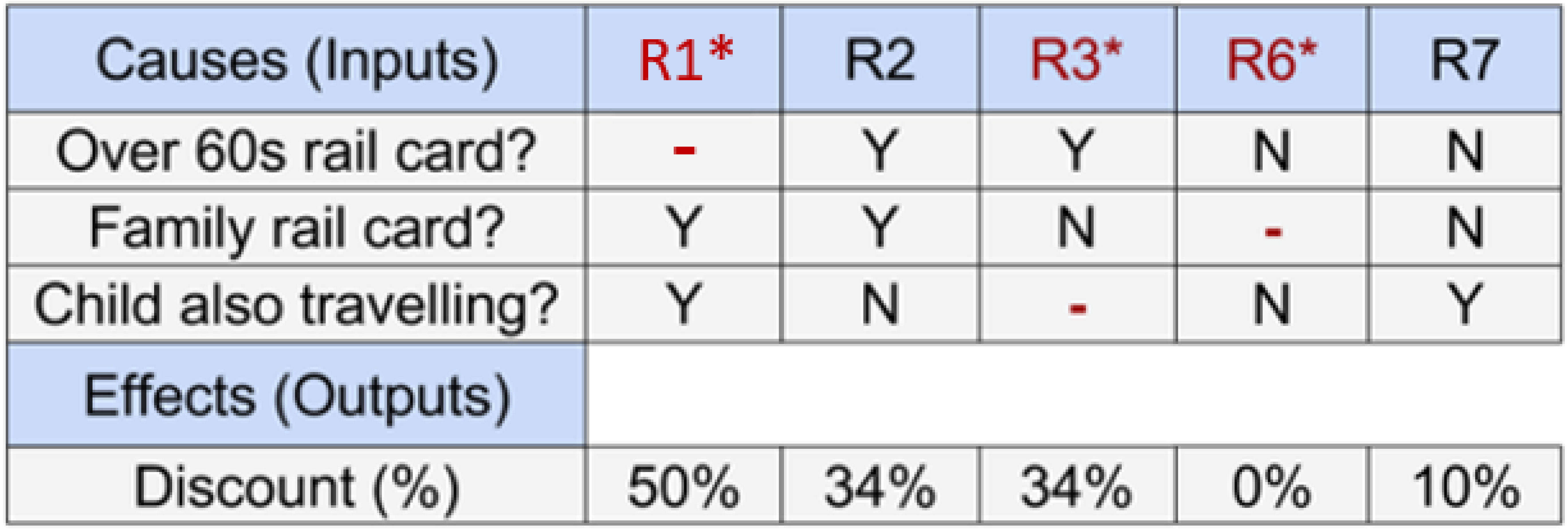
- R1 and R5 → Same effect (50% discount)
  - “Over 60s” card has no effect on the outcome
- R3 and R4 → Same effect (34% discount)
  - Third cause (children also travelling?) has no effect on the outcome
- R6 and R8 → Same effect (0% discount)
  - Having family rail card has no effect when not travelling with a child
- Rationalise table
  - Combine these with a “not applicable” entry
  - Fewer columns and fewer test cases

Exercise 1(a): Answer

Produce a decision table showing all combinations of fare types and resulting discounts

Rationalised decision table

R1*: Combines rules 1 and 5 / R3*: Combined rules 3 and 4 / R6*: Combined rules 6 and 8

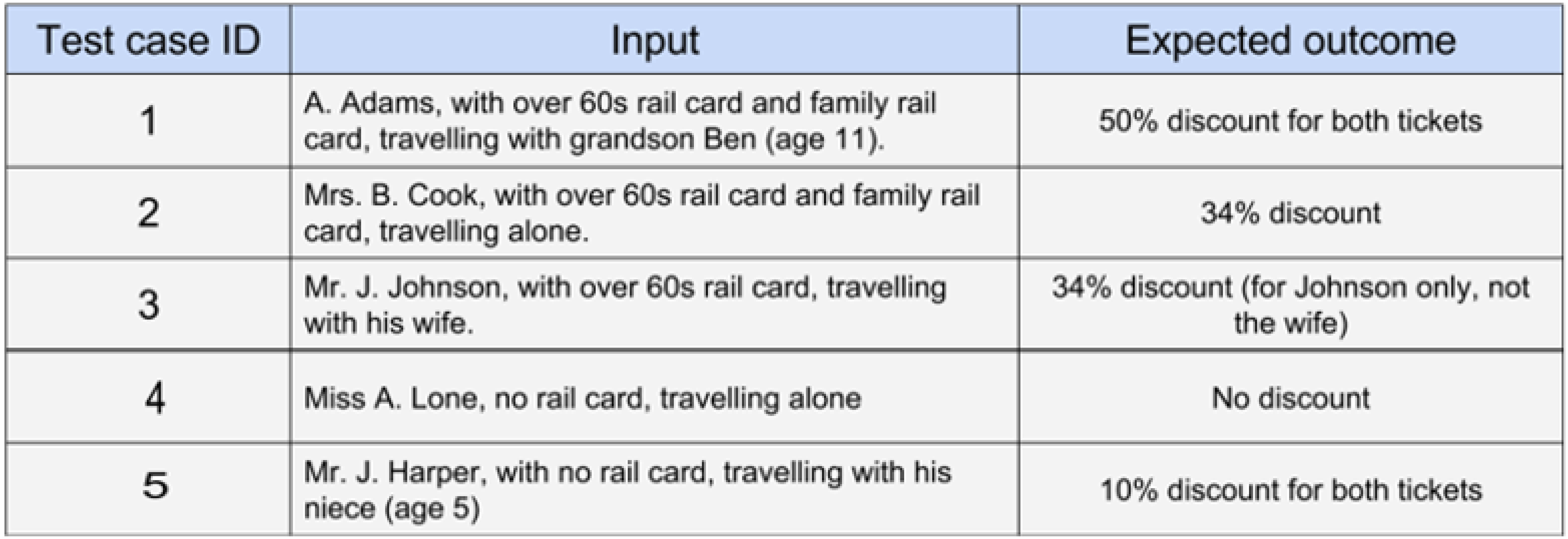


Causes (Inputs)	R1*	R2	R3*	R6*	R7
Over 60s rail card?	-	Y	Y	N	N
Family rail card?	Y	Y	N	-	N
Child also travelling?	Y	N	-	N	Y
Effects (Outputs)					
Discount (%)	50%	34%	34%	0%	10%

Exercise 1(b): Answer

Derive test cases from the decision table

Test cases for rail card scenario



Test case ID	Input	Expected outcome
1	A. Adams, with over 60s rail card and family rail card, travelling with grandson Ben (age 11).	50% discount for both tickets
2	Mrs. B. Cook, with over 60s rail card and family rail card, travelling alone.	34% discount
3	Mr. J. Johnson, with over 60s rail card, travelling with his wife.	34% discount (for Johnson only, not the wife)
4	Miss A. Lone, no rail card, travelling alone	No discount
5	Mr. J. Harper, with no rail card, travelling with his niece (age 5)	10% discount for both tickets

Exercise 1(b): Answer

Derive test cases from the decision table

Additional issues?

Does discount apply only to the traveller, or to someone travelling with them?

Specification does not explicitly state the answer

Assumptions made

Family card: Discounts apply to all travelling members

Over 60s card: Discount only applies to the individual passenger

Exercise 2: State Transitions

A website shopping basket starts out empty. As purchases are selected, they are added to the shopping basket. Items can also be removed from the shopping basket.
When the customer decides to check out, a summary of the items in the basket and the total cost are show. Customer states if the information is OK.

If the contents and the price are OK, then you leave the summary display and go to the payment system. Otherwise, you go back to shopping (so as to remove items if you want).

a. (i)Produce a state diagram showing the different states and transitions.
   (ii)Define a test, in terms of a sequence of states, to cover all transitions

b. Produce a state table. Give an example test for an invalid transition

Exercise 2(a.i): State Transitions

Produce a state diagram showing different states and transitions

Exercise 2(a.i): Clues

Produce a state diagram showing different states and transitions

1. Mapping out the different states

Empty (start state)

Nothing has been placed into the basket

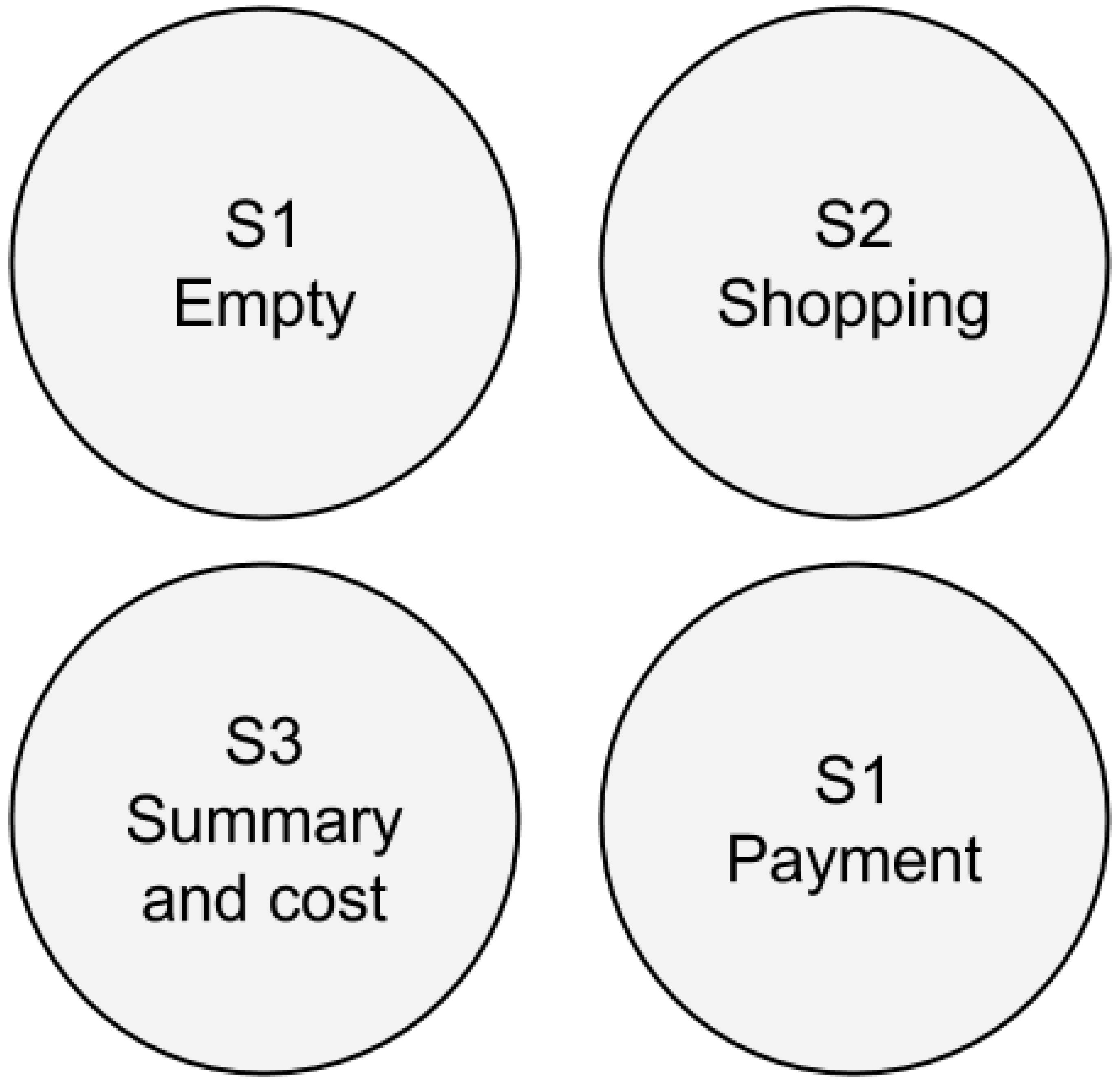
Shopping (intermediate)

There are items placed in the basket

Summary and cost (intermediate)

Overview of the items and price

Payment (final state)



Exercise 2(a.i): Clues

Produce a state diagram showing different states and transitions

2. Mapping out the transitions between states

Add item → “Empty” to “Shopping” or “Shopping” to “Shopping”

Remove item → “Shopping” to “Shopping”

Remove last item → “Shopping” to “Empty”

Check out → “Shopping” to “Summary and cost”

OK → “Summary and cost” to “Payment”

Not OK → “Summary and cost” to “Shopping”

Exercise 2(a.i): Clues

Produce a state diagram showing different states and transitions

3. Model state diagram

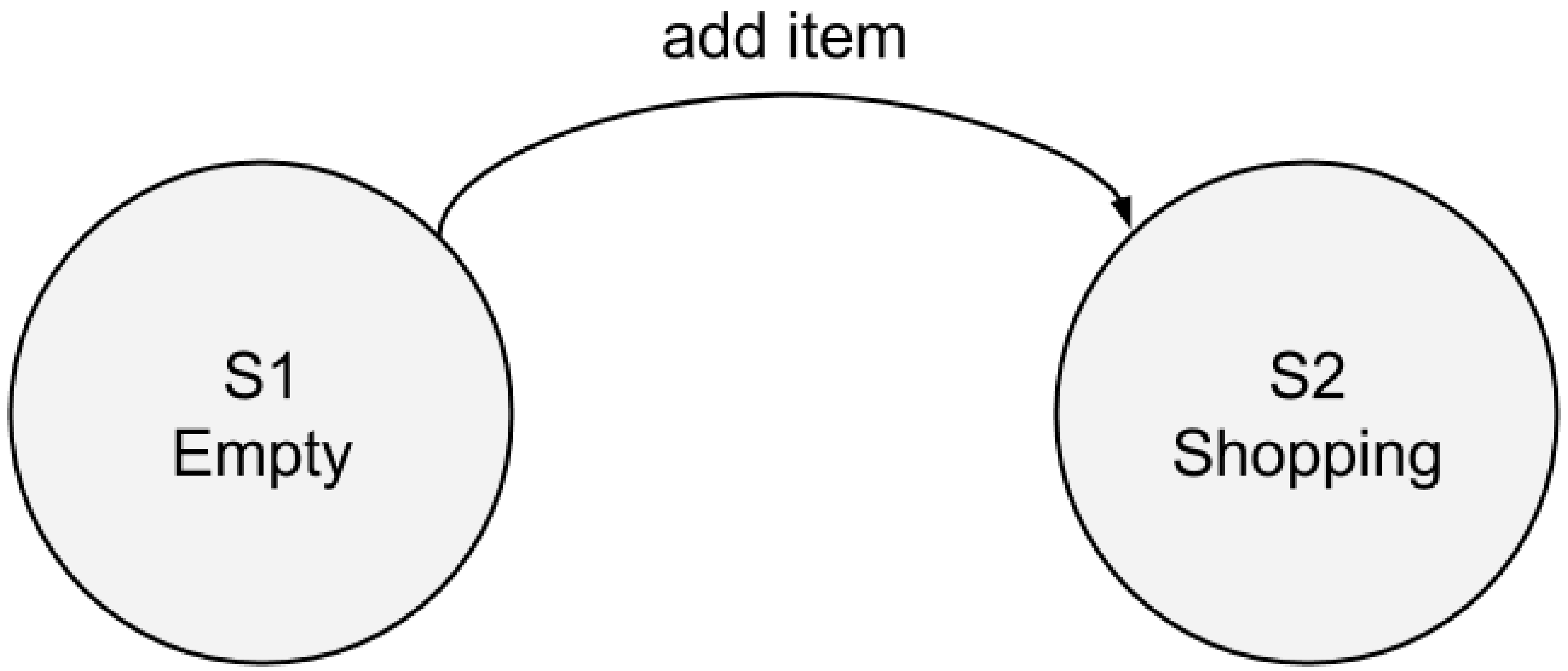
Start with the initial state "S1: Empty"

What can you do in in this state?

Add item

Which state do you reach?

"S2: Shopping"



Exercise 2(a.i): Clues

Produce a state diagram showing different states and transitions

3. Model state diagram

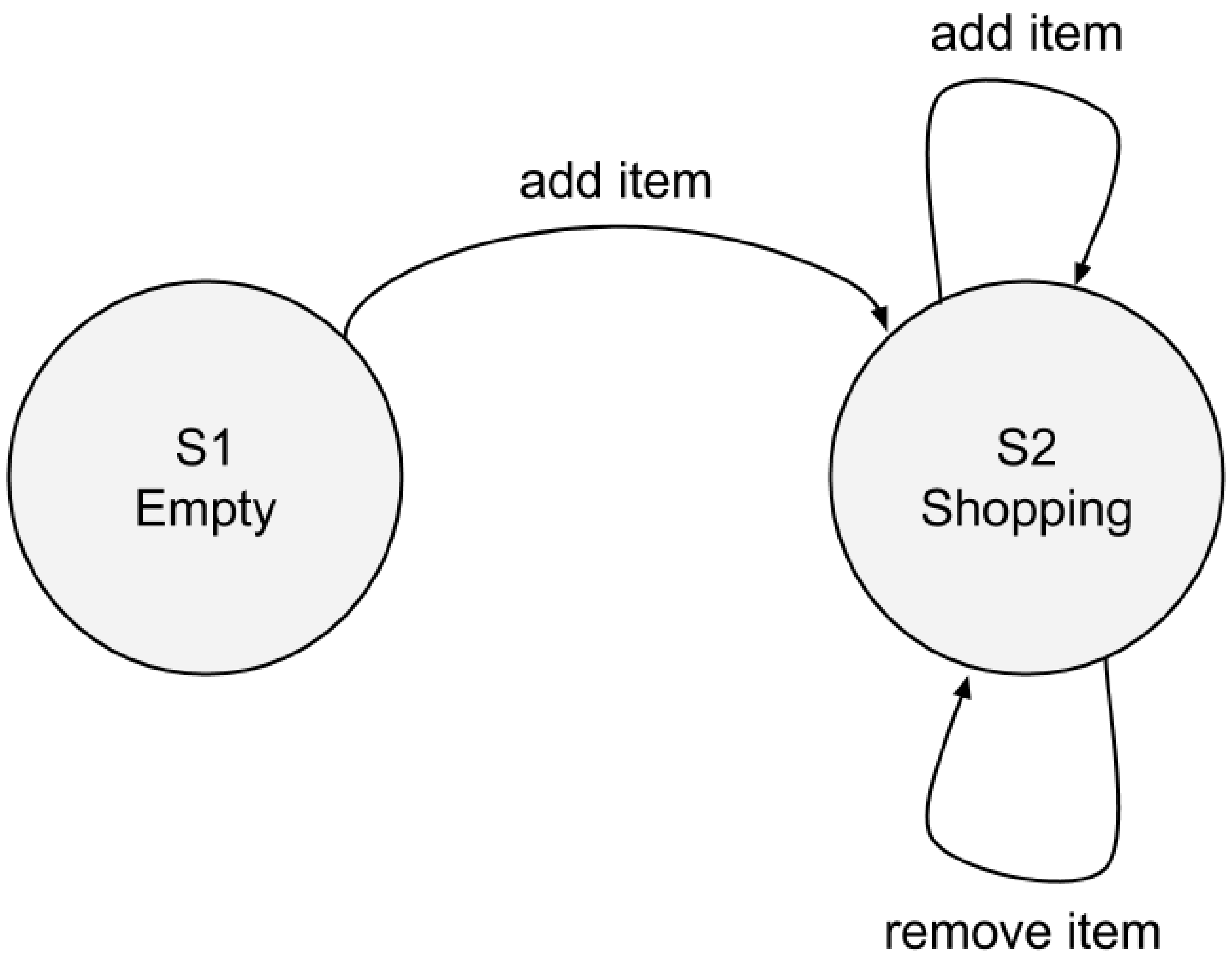
For the state “S2: Shopping”

What can you do within this state?

Add item / Remove item

Which state do you reach?

Still in “S2: Shopping”



Exercise 2(a.i): Clues

Produce a state diagram showing different states and transitions

3. Model state diagram

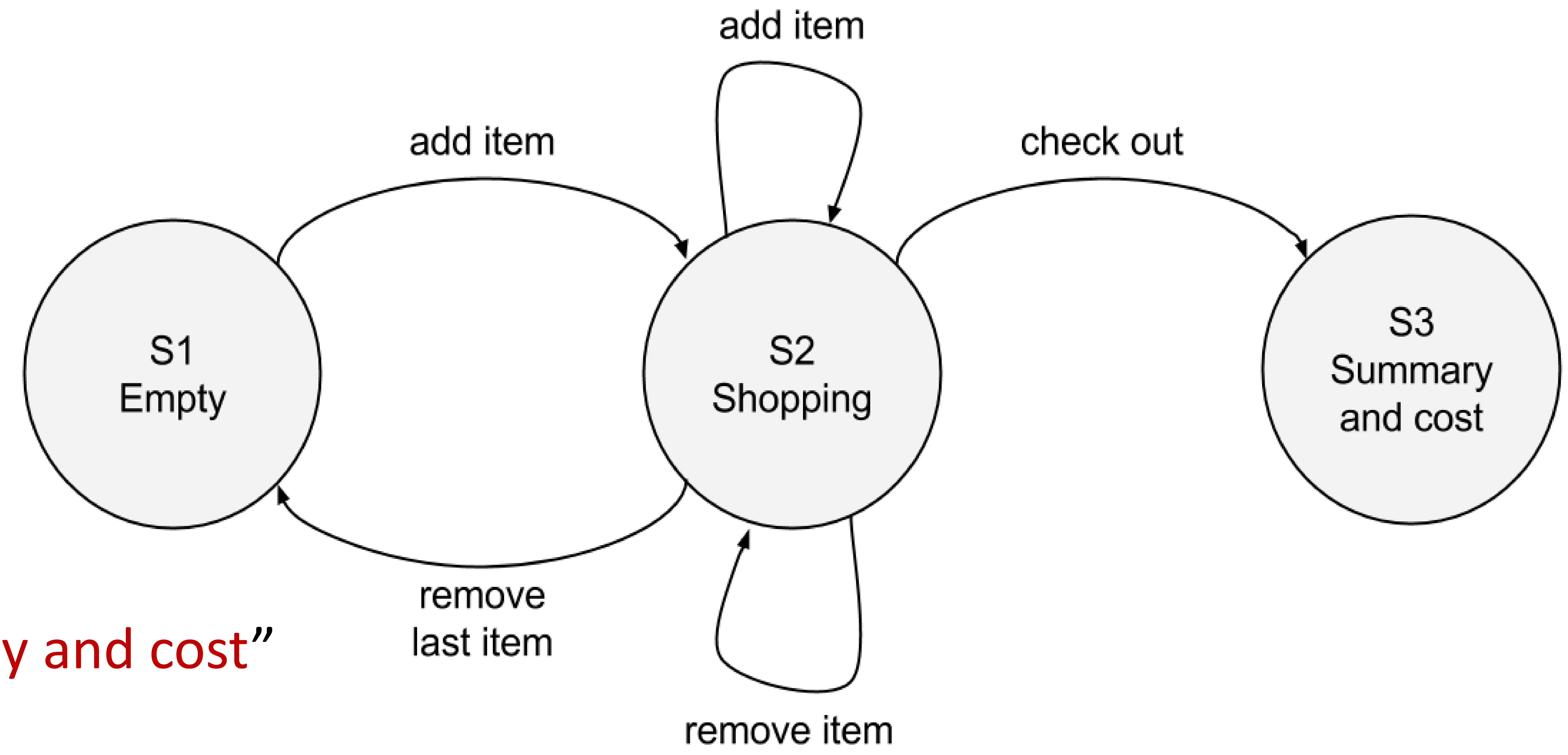
State "S2: Shopping"

Interaction with other states?

Remove last item / Check out

Which states do you reach?

"S1: Empty" and "S3: Summary and cost"



Exercise 2(a.i): Clues

Produce a state diagram showing different states and transitions

3. Model state diagram

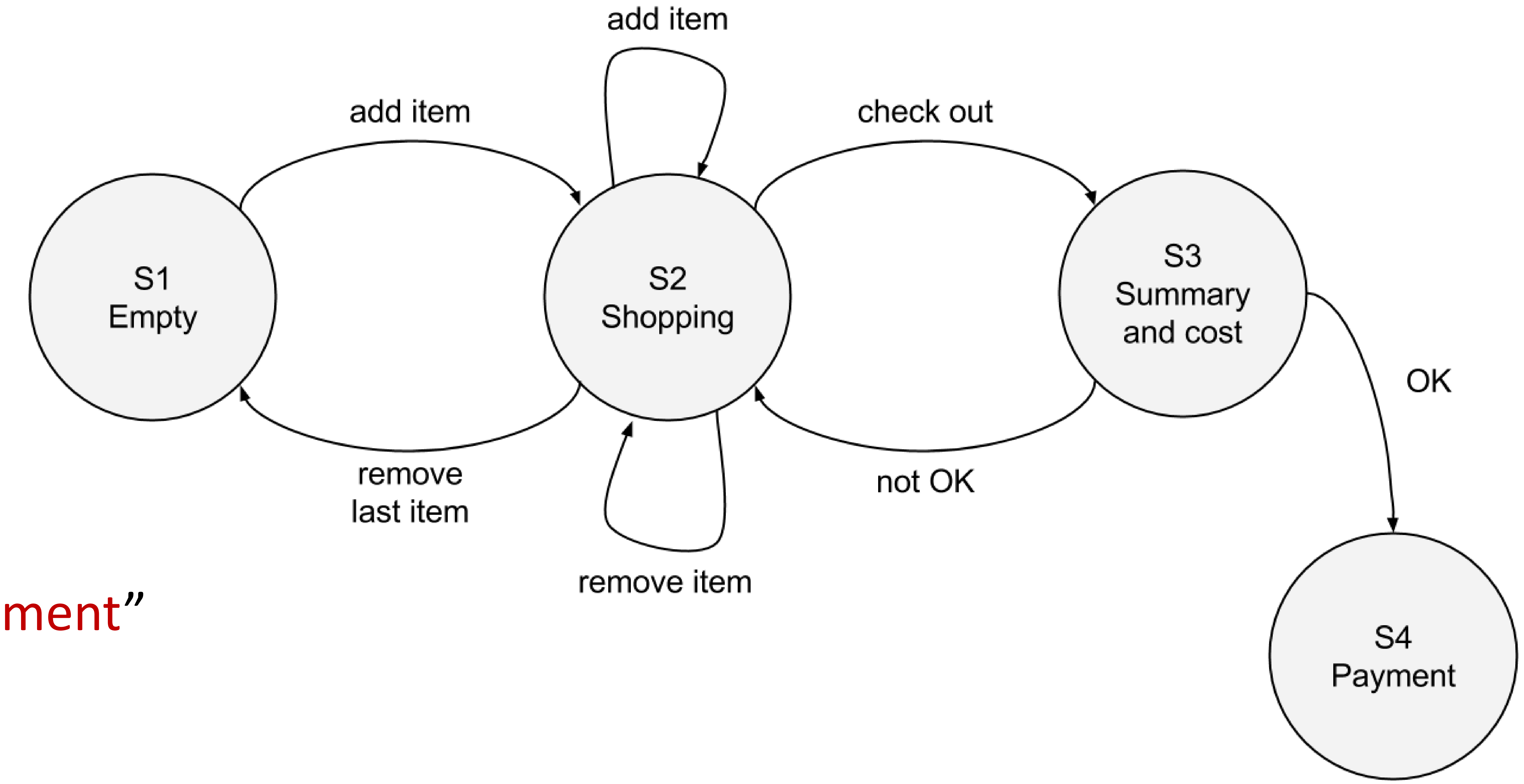
State "S3: Summary and cost"

What can you do in this state?

OK / Not OK

Which states do you reach?

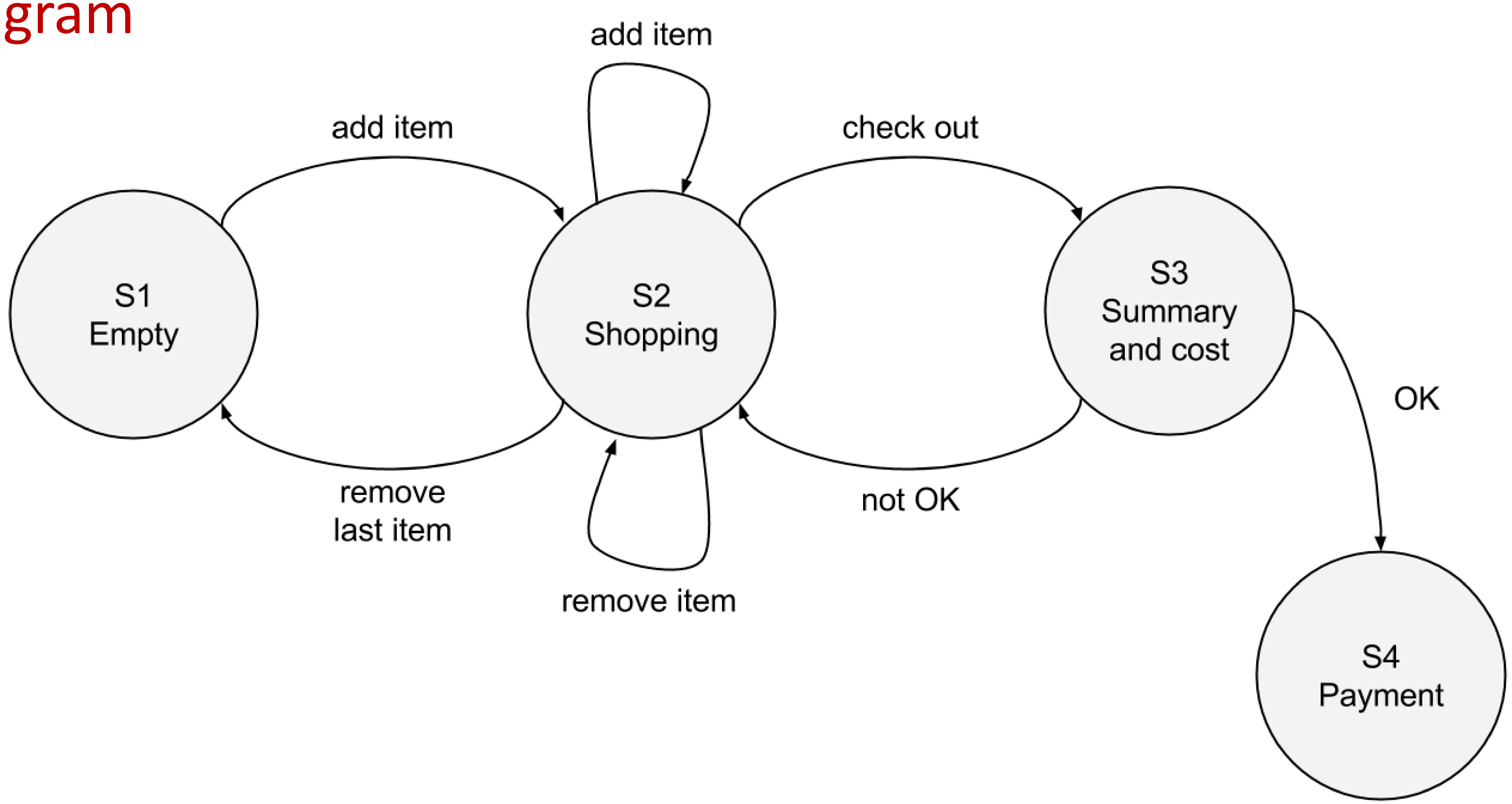
"S2: Shopping" and "S4: Payment"



Exercise 2(a.i): Answer

Produce a **state diagram** showing different **states** and **transitions**

3. Final diagram



Exercise 2(a.ii): State Transitions

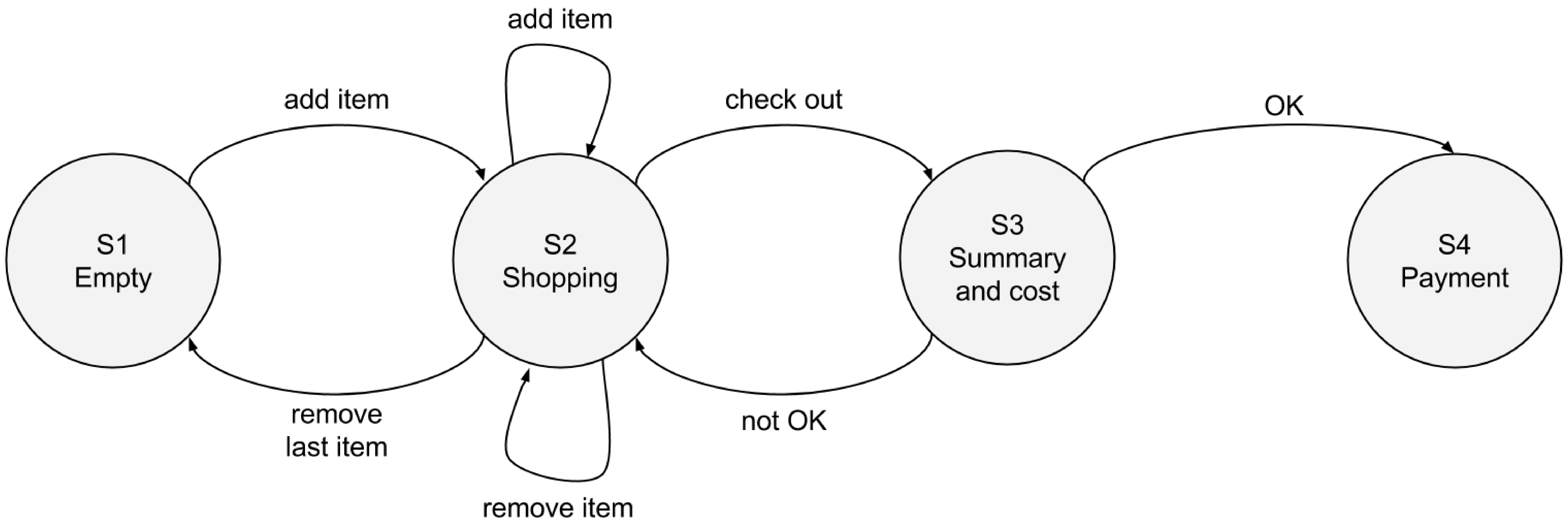
Define a test, in terms of a sequence of states, to cover all transitions

Exercise 2(a.ii): Clues

Define a **test**, in terms of a **sequence** of **states**, to cover **all transitions**

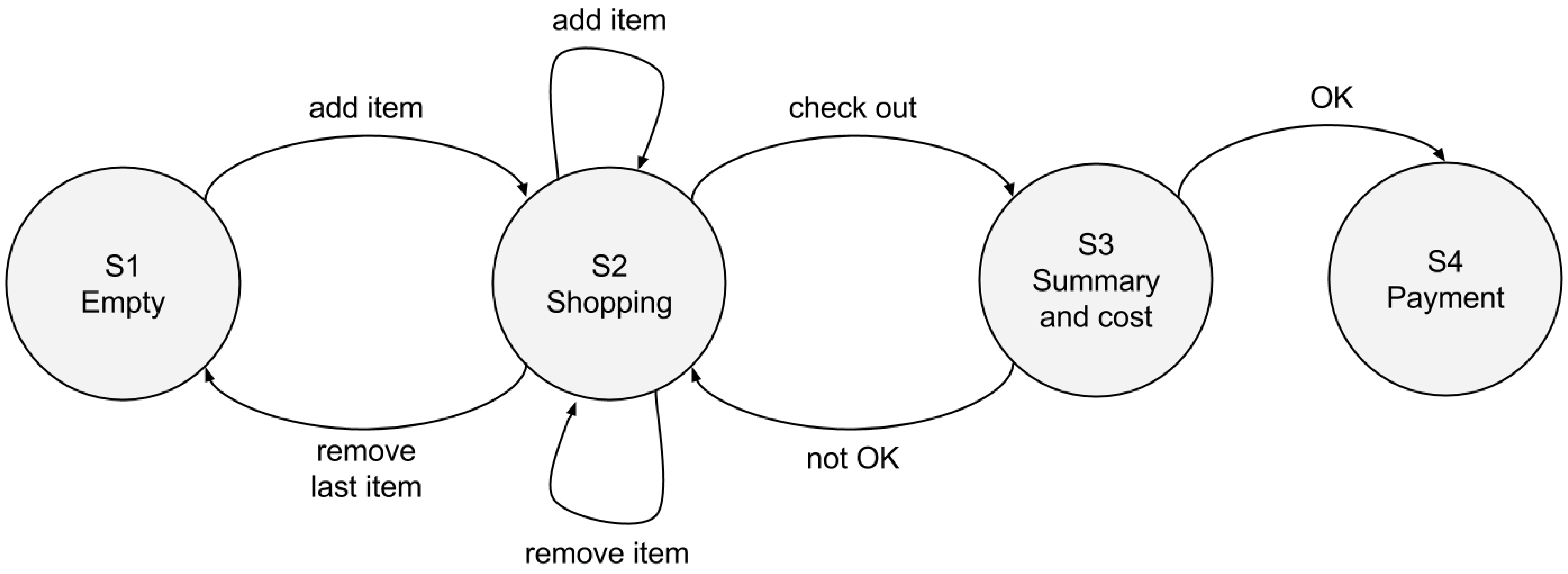
Find a path from S1 to S4, covering all transitions

That is pass every arrow in the state diagram



Exercise 2(a.ii): Clues

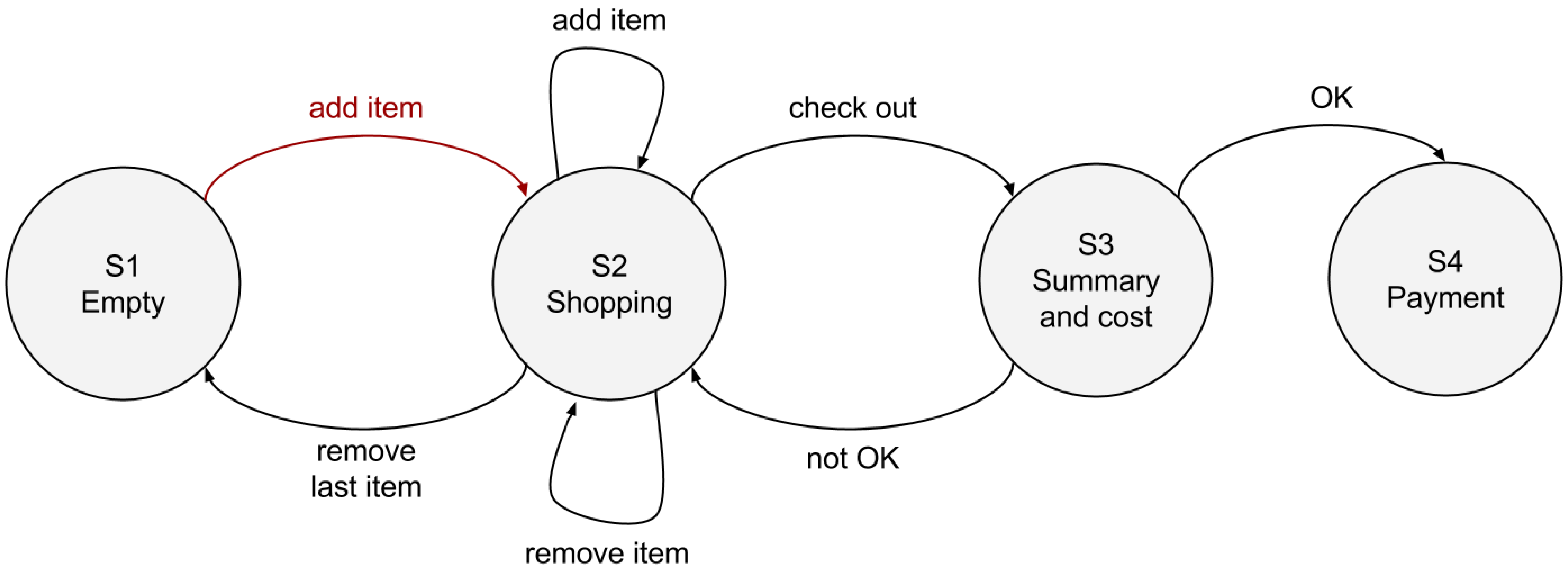
Define a **test**, in terms of a **sequence** of **states**, to cover **all transitions**



State	Event (action)

Exercise 2(a.ii): Clues

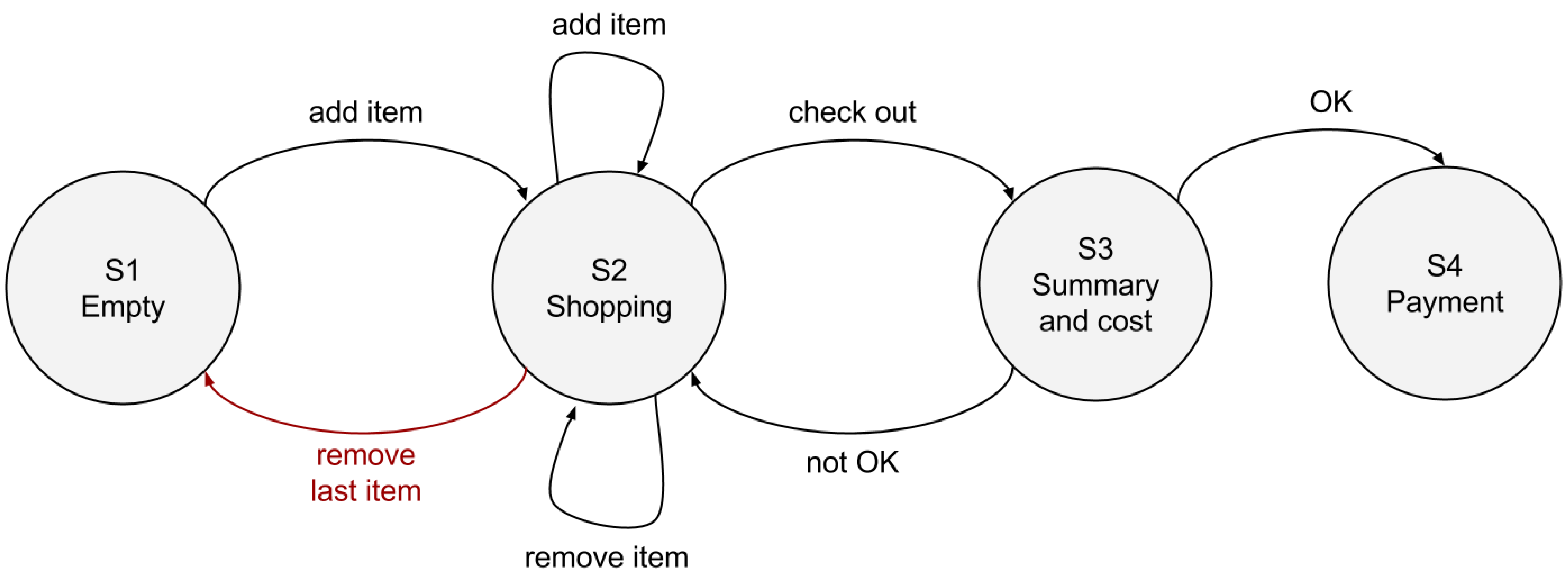
Define a test, in terms of a sequence of states, to cover all transitions



State	Event (action)
S1	Add item

Exercise 2(a.ii): Clues

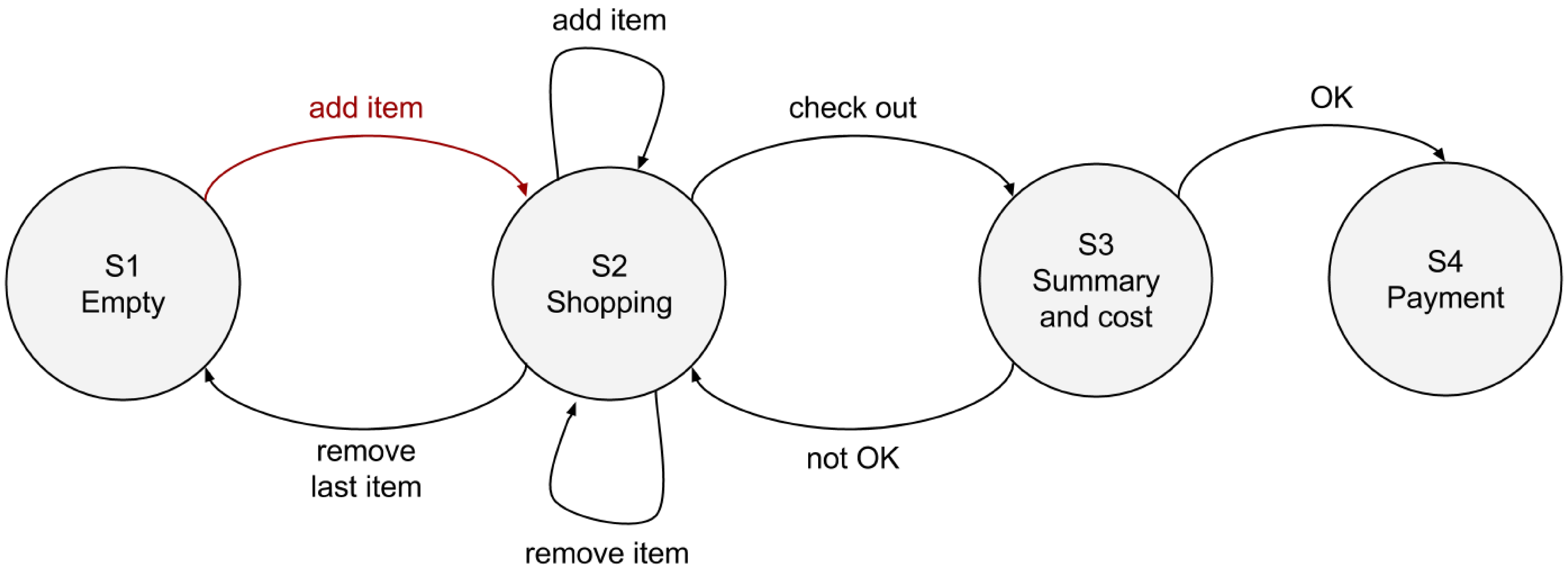
Define a **test**, in terms of a **sequence** of **states**, to cover **all transitions**



State	Event (action)
S1	Add item
S2	Remove (last) item

Exercise 2(a.ii): Clues

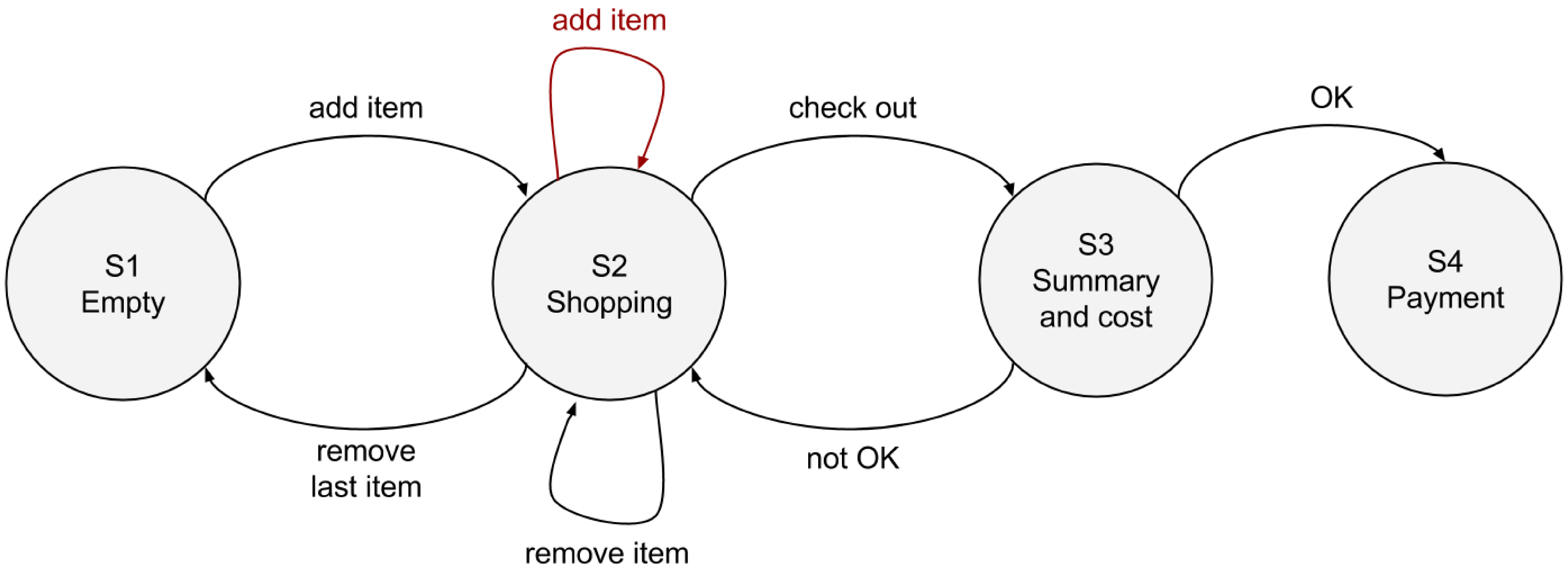
Define a **test**, in terms of a **sequence** of **states**, to cover **all transitions**



State	Event (action)
S1	Add item
S2	Remove (last) item
S1	Add item

Exercise 2(a.ii): Clues

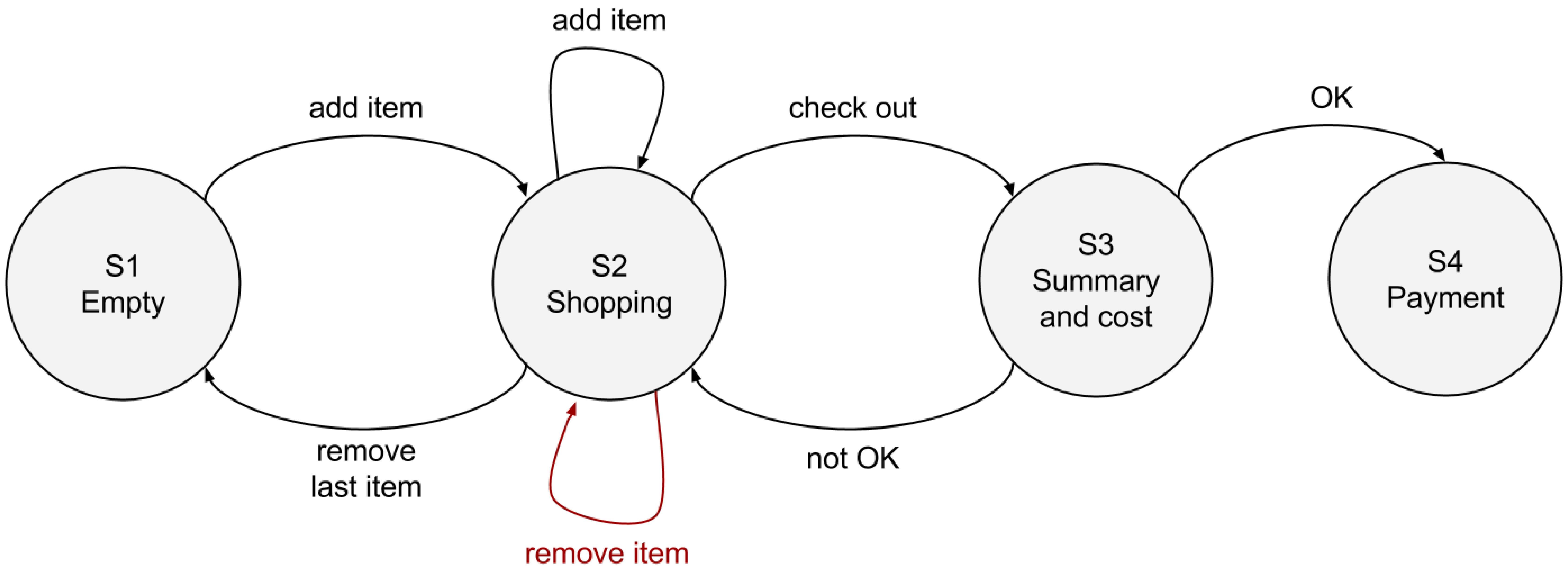
Define a **test**, in terms of a **sequence** of **states**, to cover **all transitions**



State	Event (action)
S1	Add item
S2	Remove (last) item
S1	Add item
S2	Add item

Exercise 2(a.ii): Clues

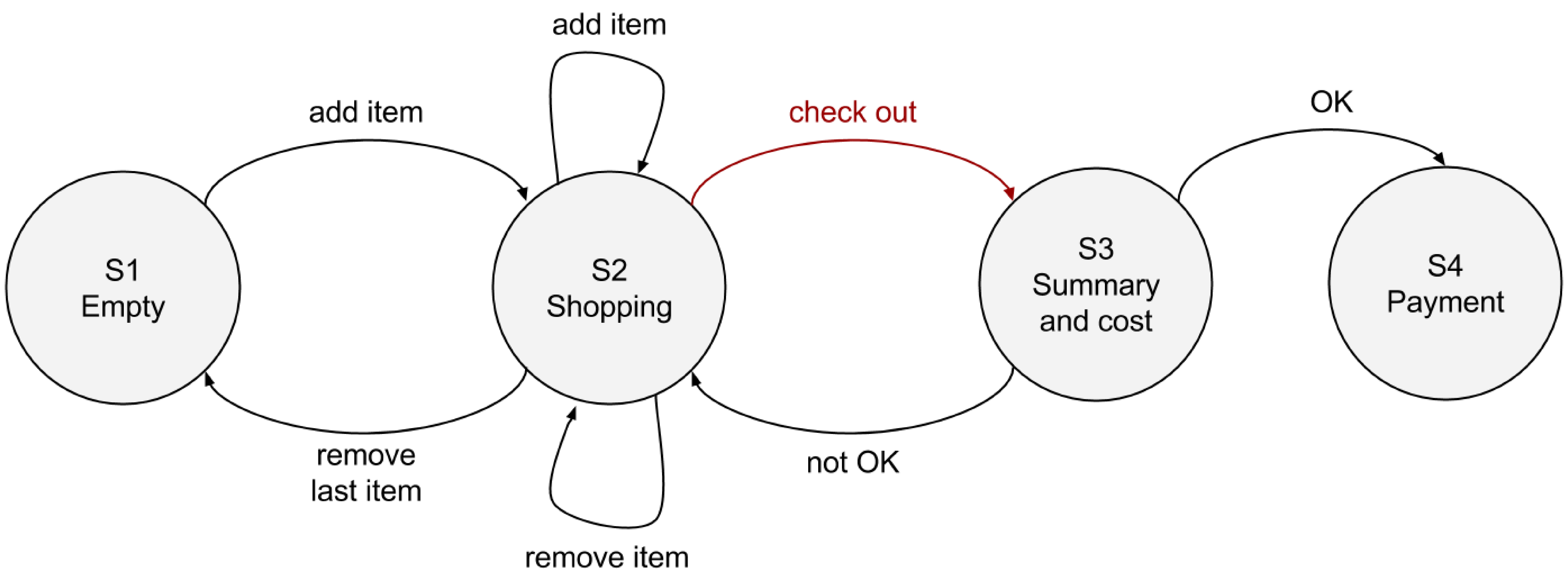
Define a **test**, in terms of a **sequence** of **states**, to cover **all transitions**



State	Event (action)
S1	Add item
S2	Remove (last) item
S1	Add item
S2	Add item
S2	Remove item

Exercise 2(a.ii): Clues

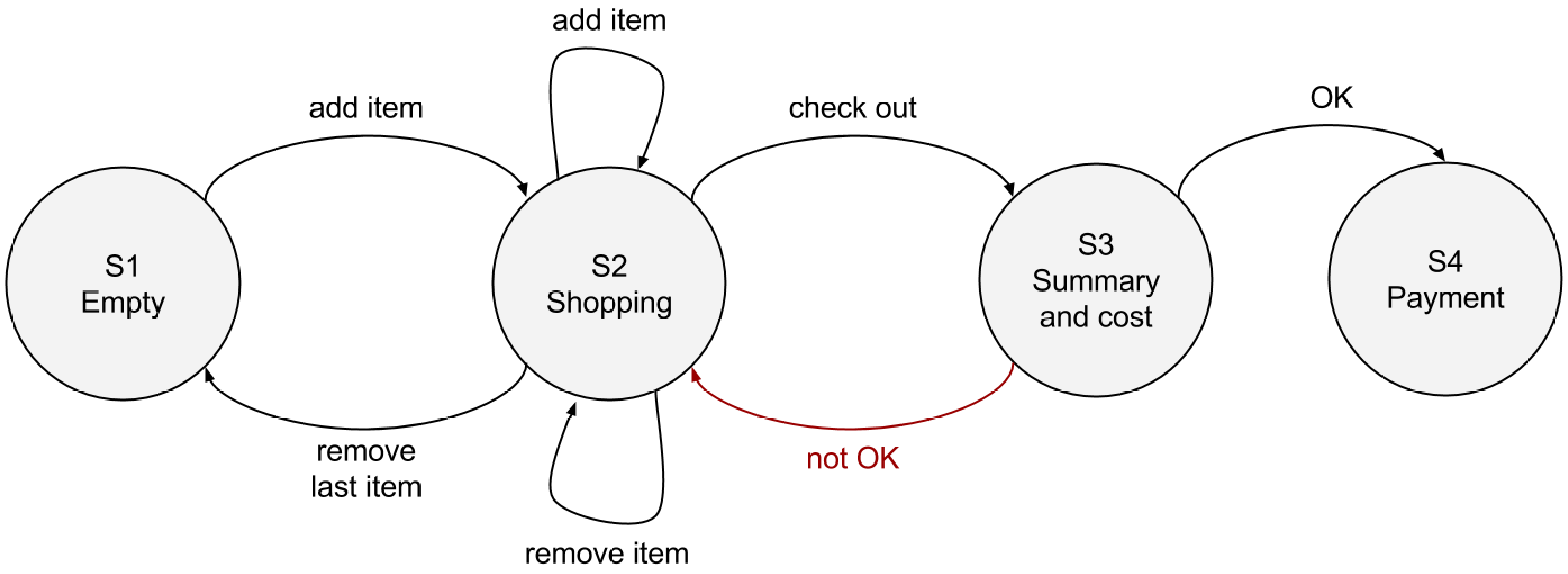
Define a **test**, in terms of a **sequence** of **states**, to cover **all transitions**



State	Event (action)
S1	Add item
S2	Remove (last) item
S1	Add item
S2	Add item
S2	Remove item
S2	Check out

Exercise 2(a.ii): Clues

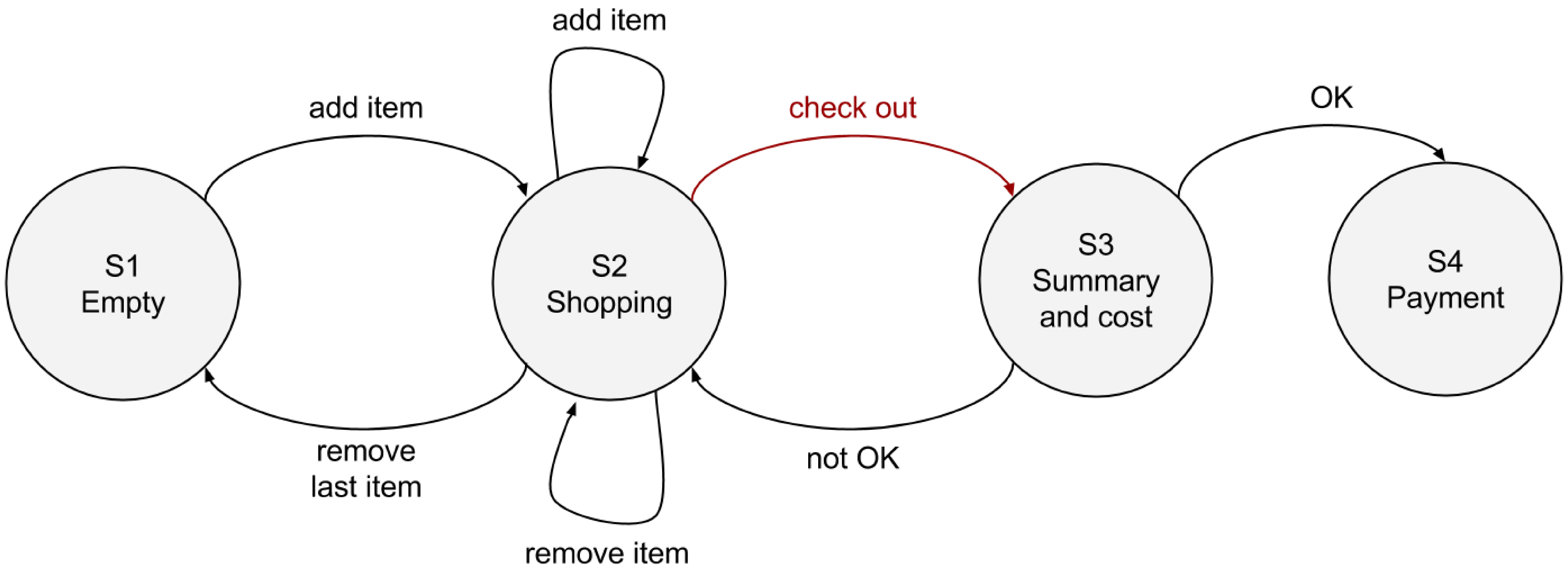
Define a **test**, in terms of a **sequence** of **states**, to cover **all transitions**



State	Event (action)
S1	Add item
S2	Remove (last) item
S1	Add item
S2	Add item
S2	Remove item
S2	Check out
S3	Not OK

Exercise 2(a.ii): Clues

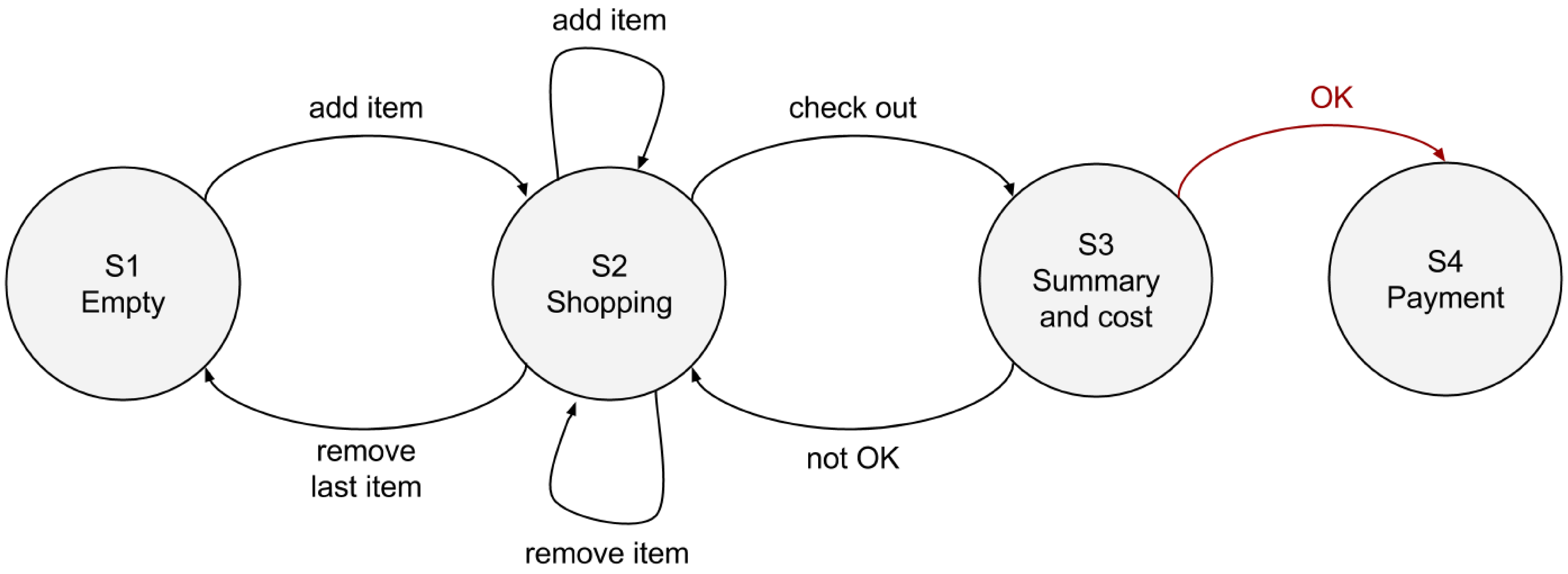
Define a **test**, in terms of a **sequence** of **states**, to cover **all transitions**



State	Event (action)
S1	Add item
S2	Remove (last) item
S1	Add item
S2	Add item
S2	Remove item
S2	Check out
S3	Not OK
S2	Check out

Exercise 2(a.ii): Clues

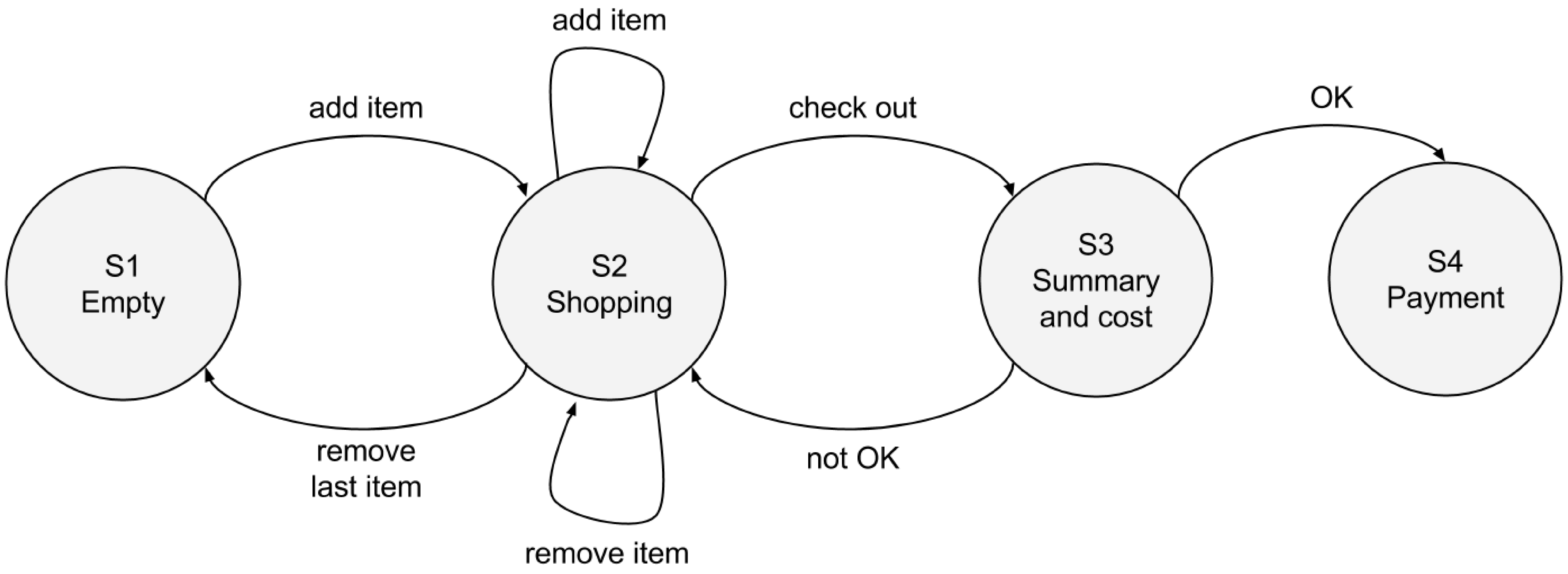
Define a test, in terms of a sequence of states, to cover all transitions



State	Event (action)
S1	Add item
S2	Remove (last) item
S1	Add item
S2	Add item
S2	Remove item
S2	Check out
S3	Not OK
S2	Check out
S3	OK

Exercise 2(a.ii): Answer

Define a **test**, in terms of a **sequence** of **states**, to cover **all transitions**



State	Event (action)
S1	Add item
S2	Remove (last) item
S1	Add item
S2	Add item
S2	Remove item
S2	Check out
S3	Not OK
S2	Check out
S3	OK
S4	-

Exercise 2(b): State Transitions

Produce a state table. Give an example test for an invalid transition

Exercise 2(b): Clues

Produce a **state table**. Give an **example** test for an **invalid transition**

State table

Maps out states and transitions in tabular form

State (Event)	Add item	Remove item	Remove last item	Check out	OK	Not OK
S1: Empty						
S2: Shopping						
S3: Summary						
S4: Payment						

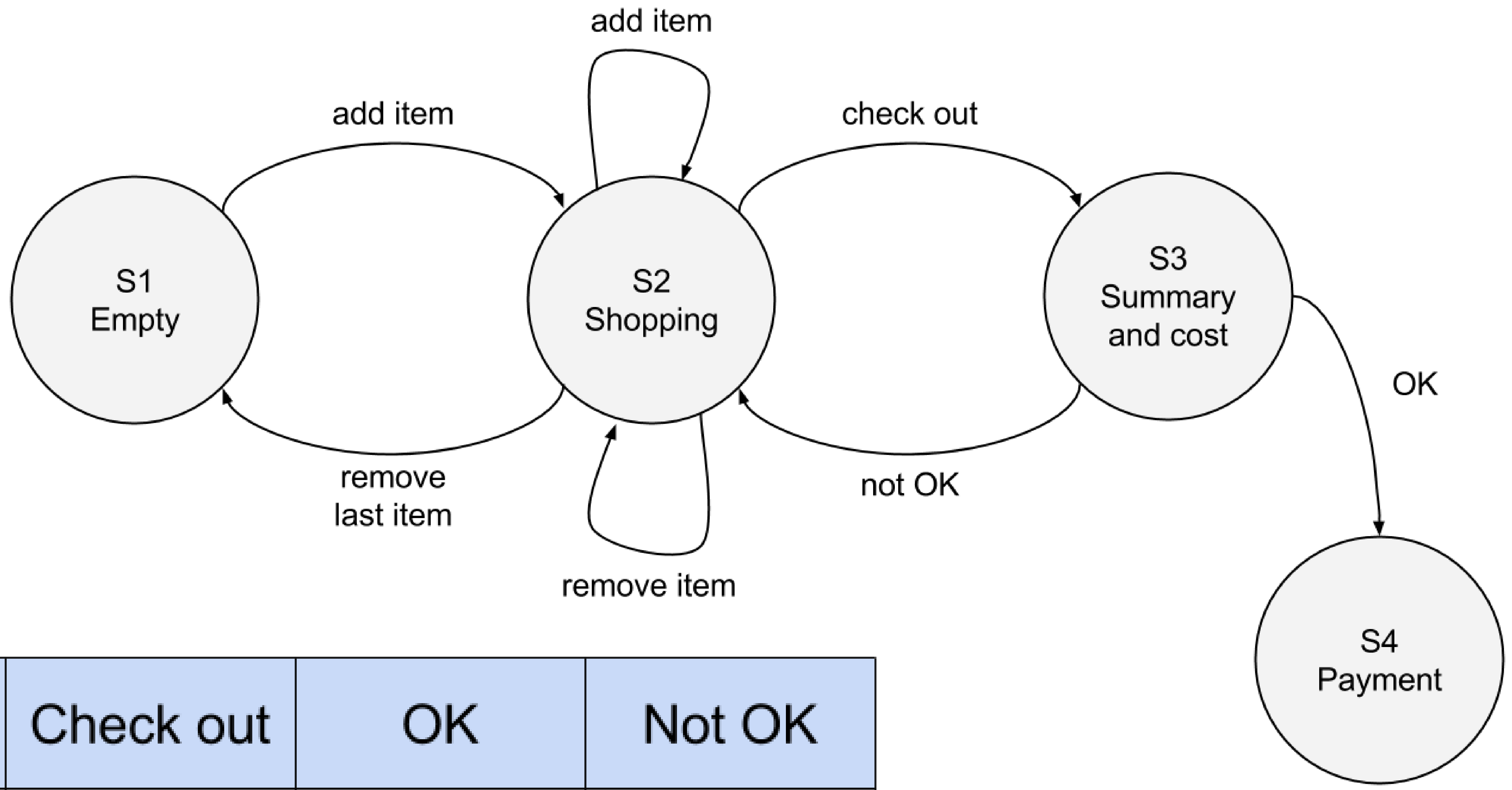
Exercise 2(b): Clues

Produce a **state table**. Give an **example** test for an **invalid transition**

S1: Empty

What states can we reach from S1?

Through which transitions?



State (Event)	Add item	Remove item	Remove last item	Check out	OK	Not OK
S1: Empty	S2	-	-	-	-	-
S2: Shopping						
S3: Summary						
S4: Payment						

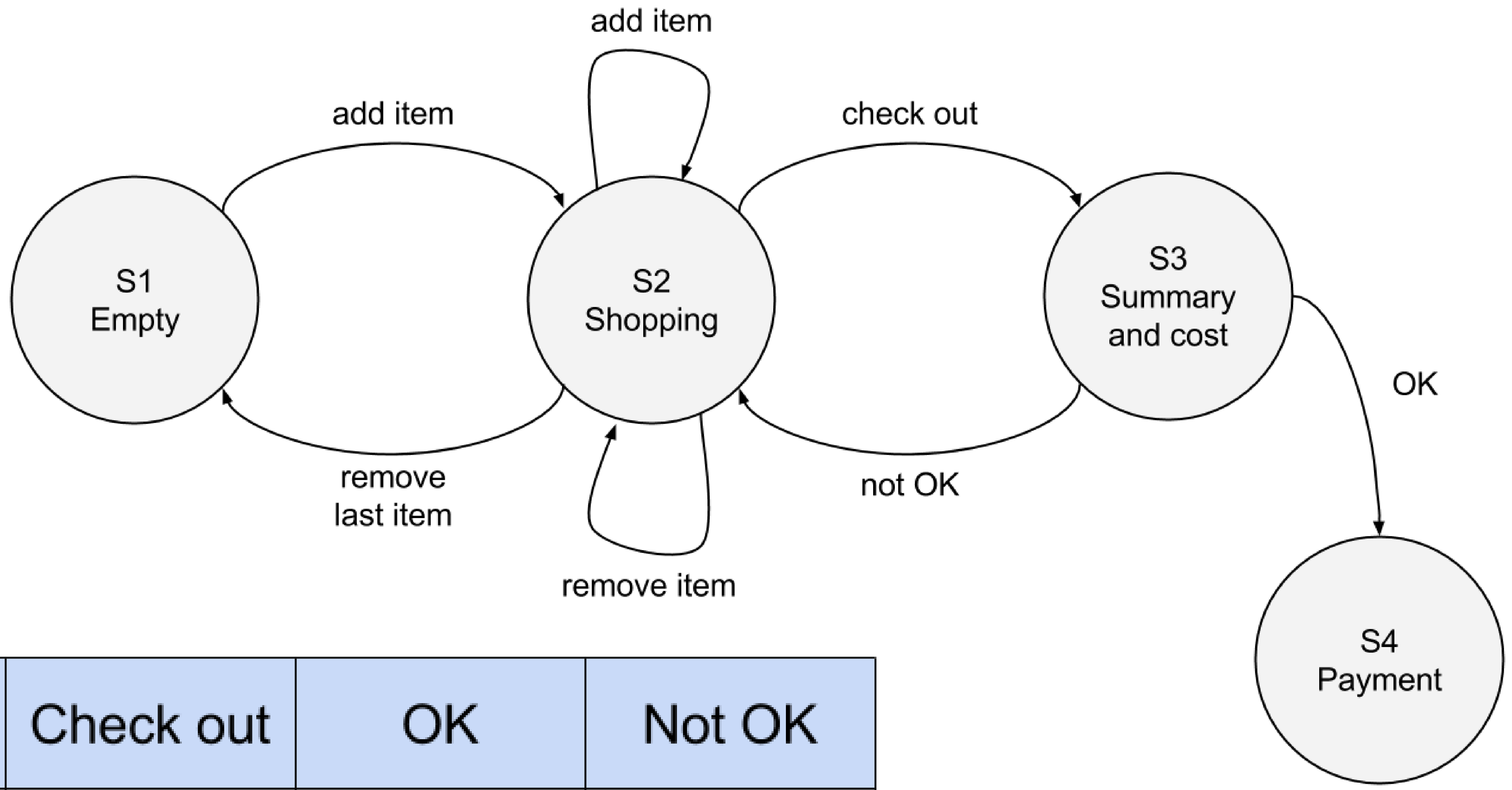
Exercise 2(b): Clues

Produce a **state table**. Give an **example** test for an **invalid transition**

S2: Shopping

What states can we reach from S2?

Through which transitions?



State (Event)	Add item	Remove item	Remove last item	Check out	OK	Not OK
S1: Empty	S2	-	-	-	-	-
S2: Shopping	S2	S2	S1	S3	-	-
S3: Summary						
S4: Payment						

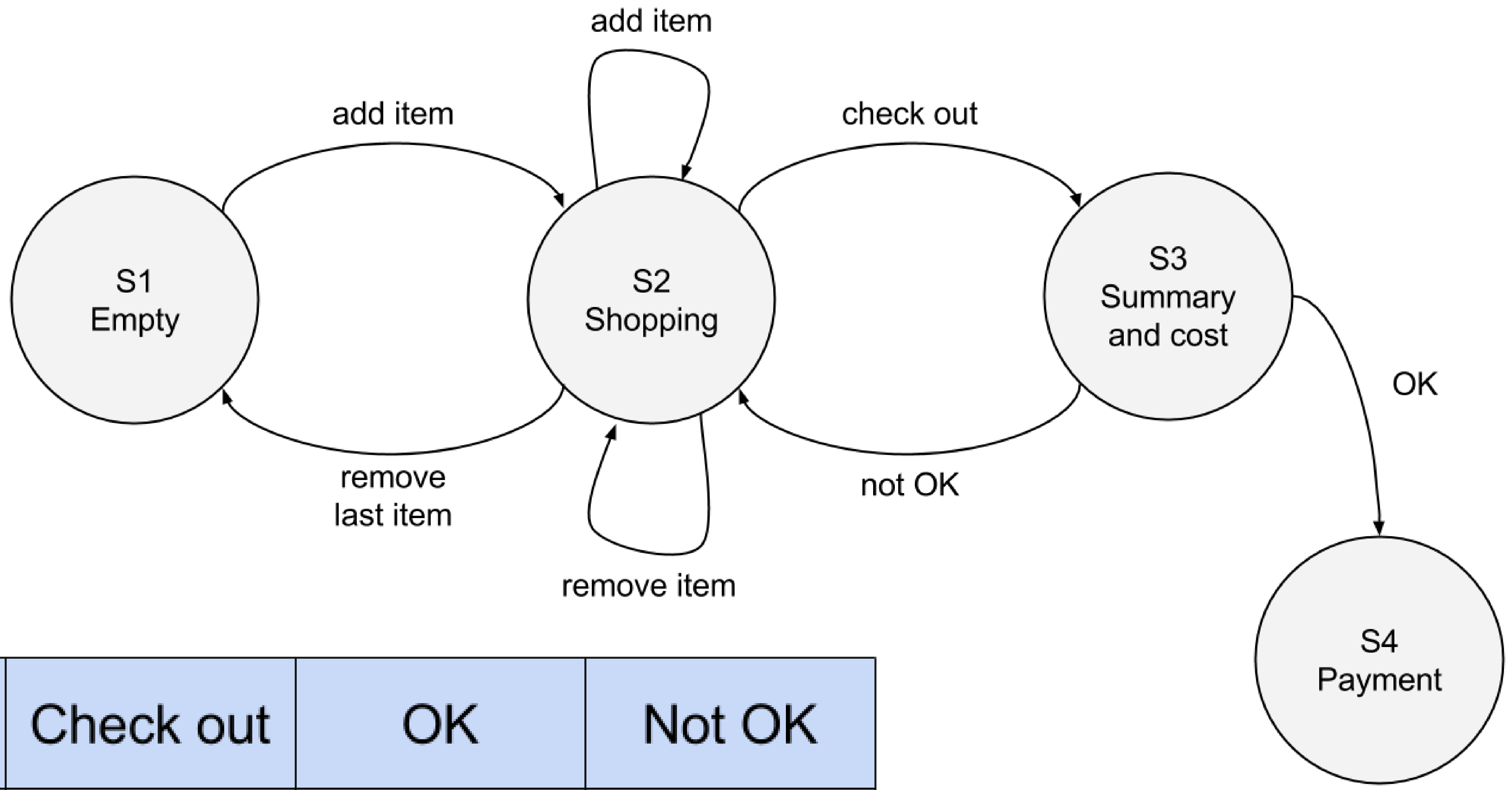
Exercise 2(b): Clues

Produce a **state table**. Give an **example** test for an **invalid transition**

S3: Summary and cost

What states can we reach from S3?

Through which transitions?



State (Event)	Add item	Remove item	Remove last item	Check out	OK	Not OK
S1: Empty	S2	-	-	-	-	-
S2: Shopping	S2	S2	S1	S3	-	-
S3: Summary	-	-	-	-	S2	S4
S4: Payment						

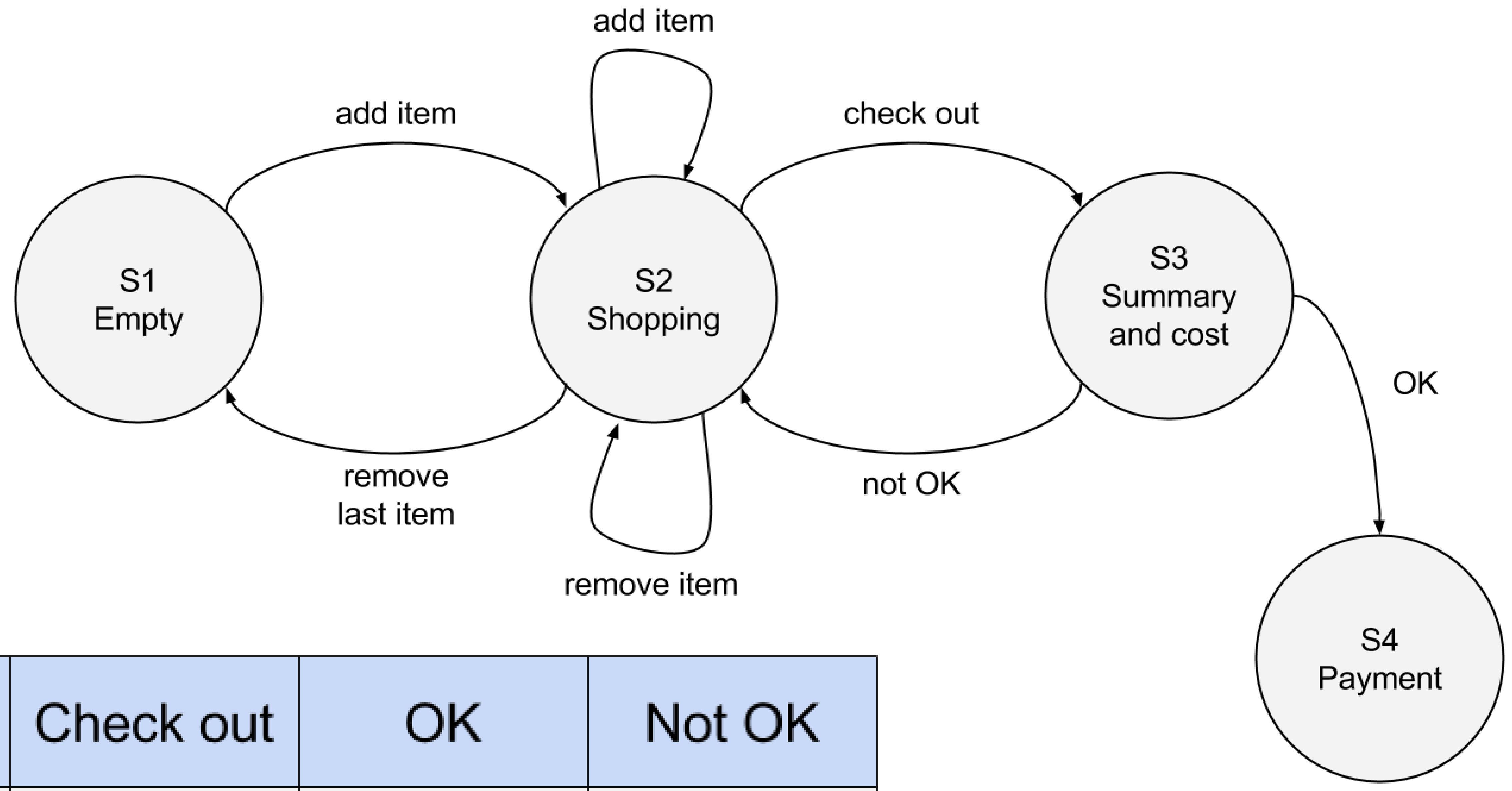
Exercise 2(b): Answer

Produce a **state table**. Give an **example** test for an **invalid transition**

S4: Payment

What states can we reach from S4?

Through which transitions?



State (Event)	Add item	Remove item	Remove last item	Check out	OK	Not OK
S1: Empty	S2	-	-	-	-	-
S2: Shopping	S2	S2	S1	S3	-	-
S3: Summary	-	-	-	-	S2	S4
S4: Payment	-	-	-	-	-	-

Exercise 3: Statement and Decision

A vending machine dispenses either hot or cold drinks.

If you choose a hot drink (e.g. tea or coffee), it asks if you want milk (added if required).

Ten it asks if you want sugar (added if required)

Finally, the drink is dispensed.

Exercise 3(a)

Draw a control flow diagram for this example

Hint: Regard the selection of the type of drink as one statement

Exercise 3(a): Clues

Draw a control flow diagram for this example

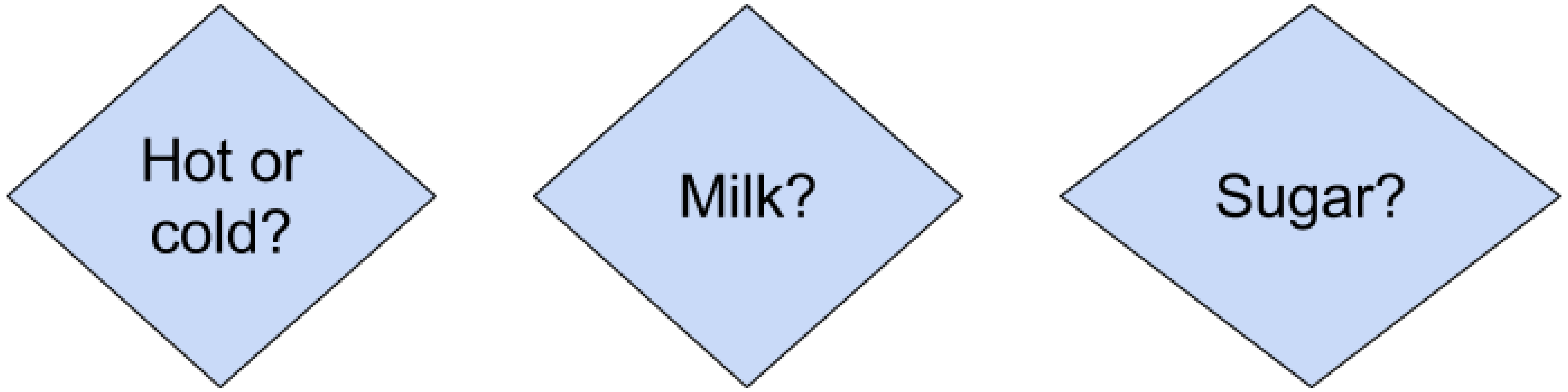
1. Map out the different *controls* for the scenario

What is being controlled?

Hot or cold drink

Milk or no milk

Sugar or no sugar



2. Represent each control with a *diamond* shape

These controls will lead to decisions

E.g. Choosing a “hot” drink, or choosing “no milk”.

Exercise 3(a): Clues

Draw a control flow diagram for this example

3. Map out the different *outcomes* (statements) for each control

What are the outcomes?

Hot drink → Select drink (coffee or tea)

Cold drink → Select drink (water or soda)

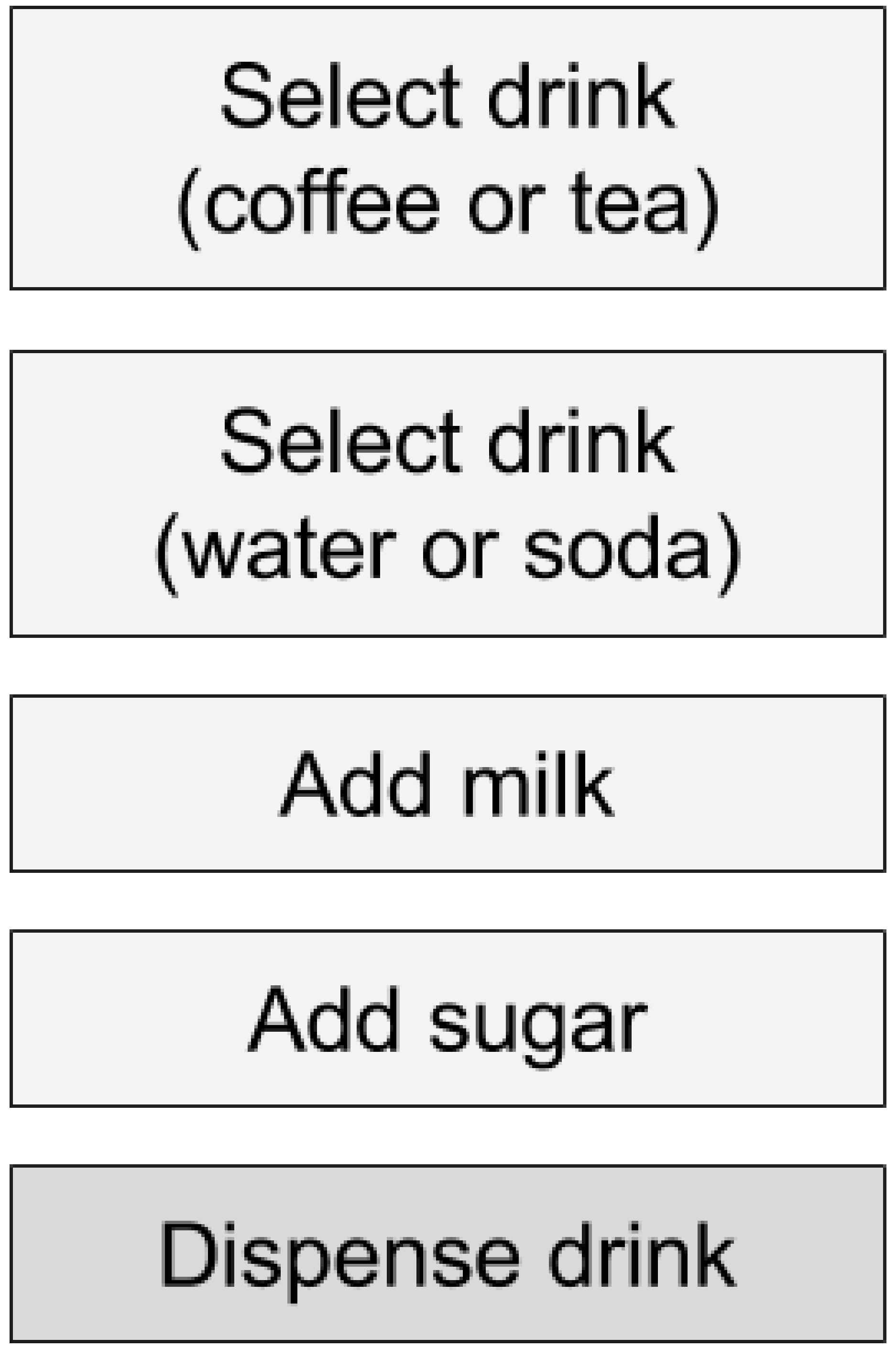
Milk → Add milk

No milk → Nothing happens

Sugar → Add sugar

No sugar → Nothing

4. Represent the statements with rectangles



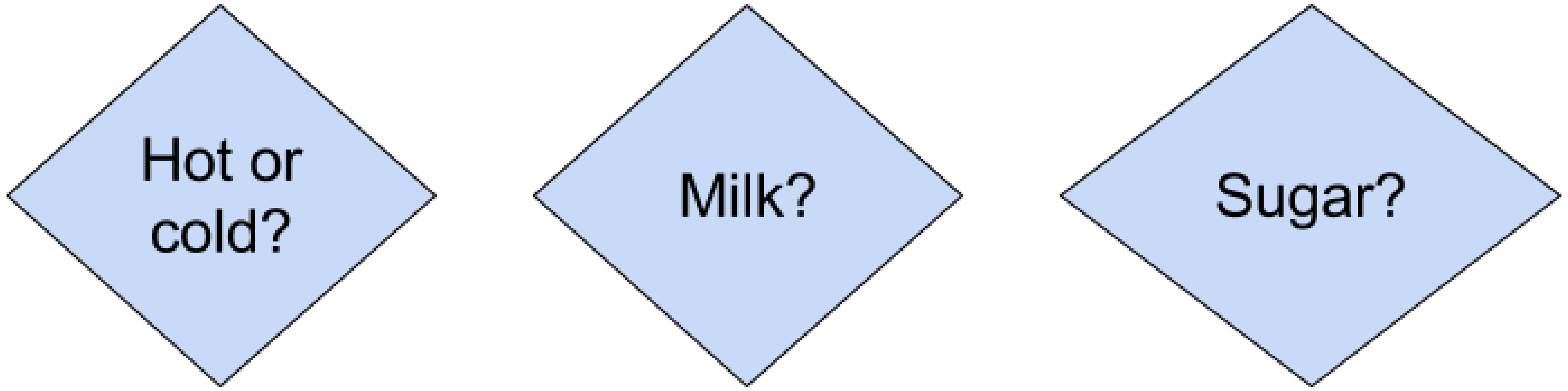
Exercise 3(a): Clues

Draw a control flow diagram for this example

5. Map out the different *decisions* (statements) for each control

What are the outcomes of each *question*?

Which statements do they lead to?



Hot / Cold
[Select drink (coffee or tea)]
[Select drink (water or soda)]

Yes / No
[Add milk]
N/A

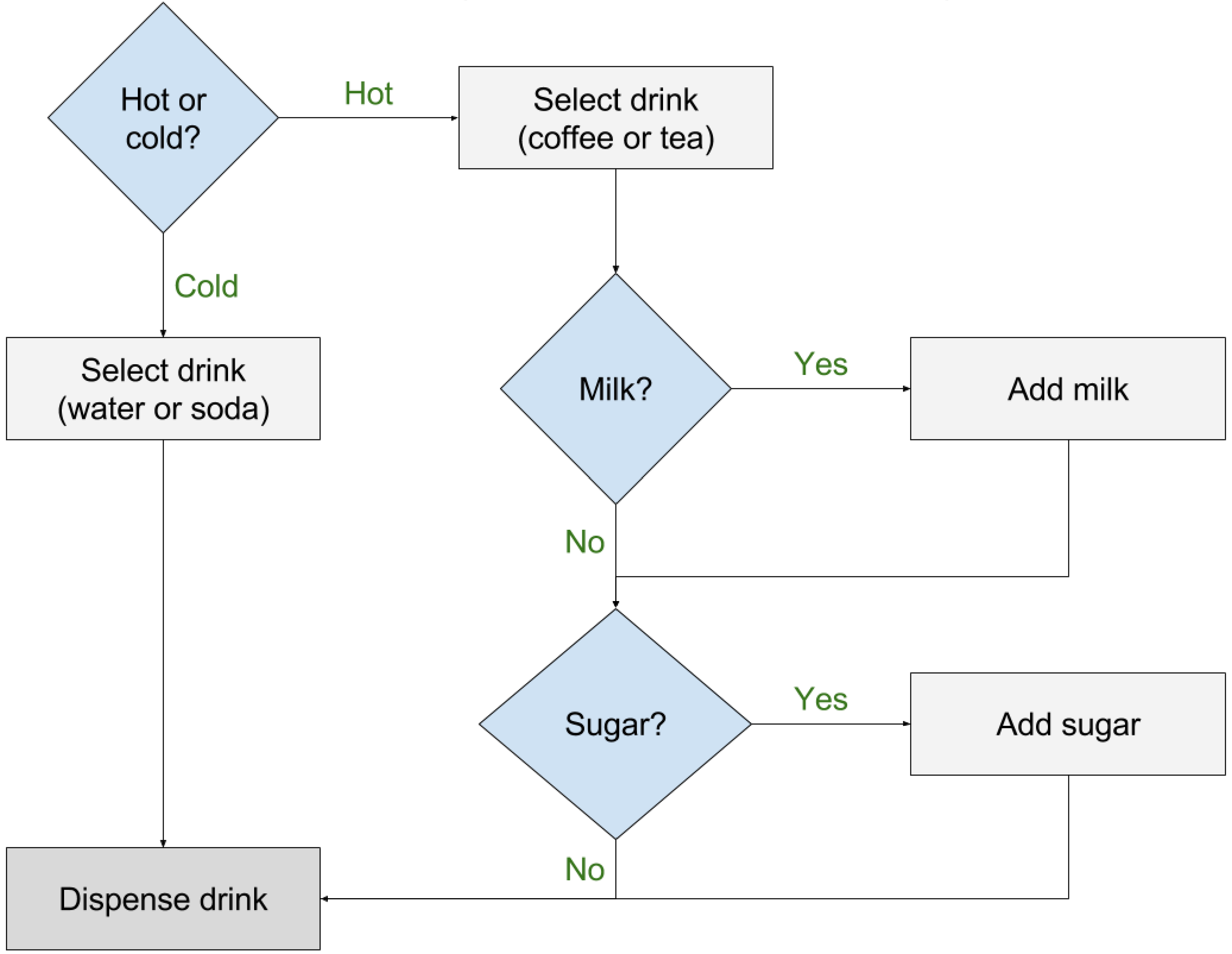
Yes / No
[Add sugar]
N/A

6. Represent the outcomes with arrows in the diagram

Exercise 3(a): Answer

Draw a control flow diagram for this example

7. Construct the control flow diagram combining all elements



Exercise 3(b)

Given the following tests, what is the statement coverage achieved? What is the decision coverage achieved?

Test 1: Cold drink
Test 2: Hot drink with milk and sugar

Exercise 3(b): Clues

Statement and decision coverage

Test 1:

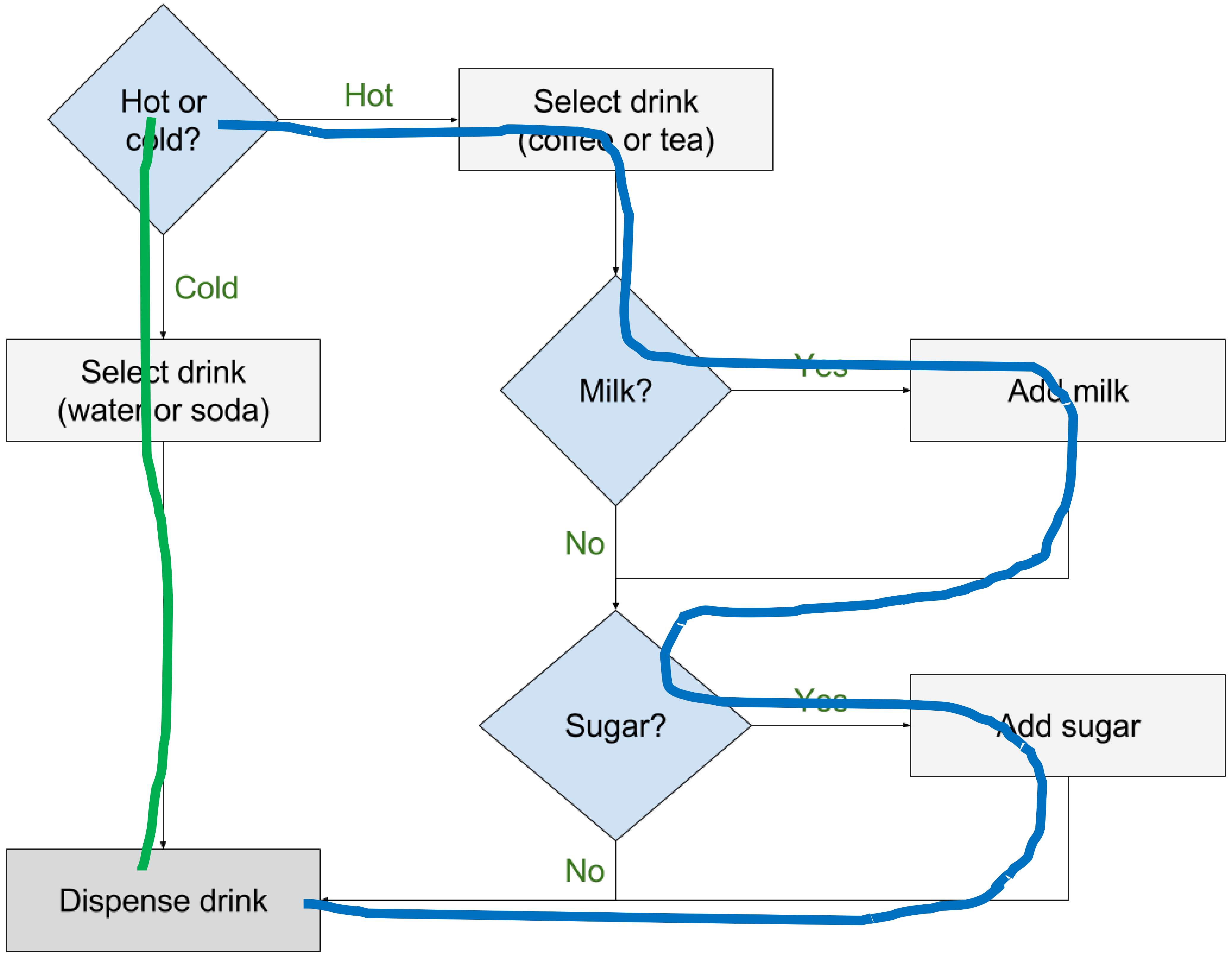
Cold drink

Test 2:

Hot drink with milk and sugar

What is the statement coverage?

What is the decision coverage?



Exercise 3(b): Answer and clues

Statement and decision coverage

Statement coverage

100 % statement coverage

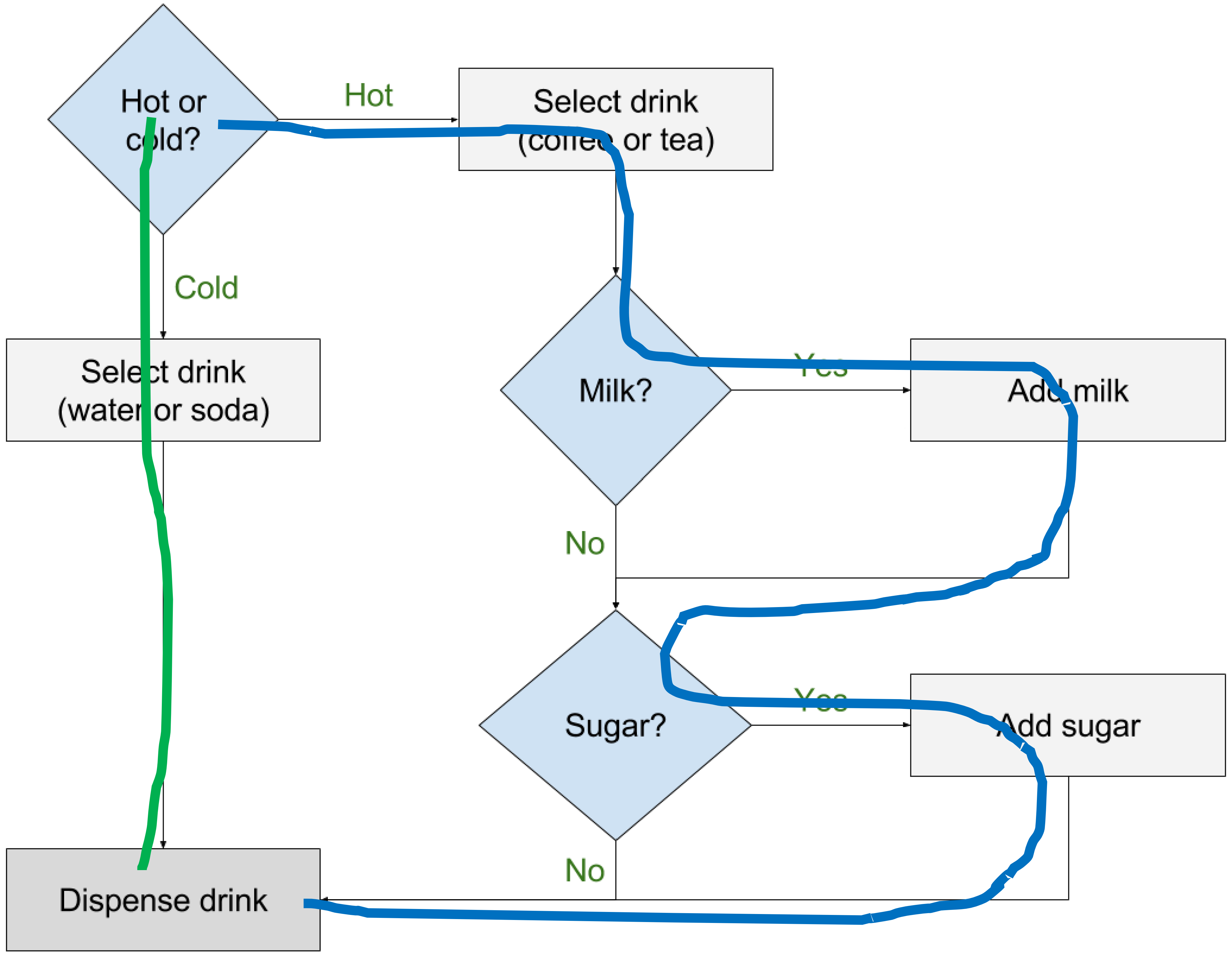
Every statement has been covered

(All boxes have been touched)

What is the decision coverage?

How many decision outcomes exist?

How many decision outcomes exercised?



Exercise 3(b): Answer

Statement and decision coverage

What is the decision coverage?

How many decision outcomes exist?

Hot / Cold / Yes / No / Yes / No

6 decision outcomes in total

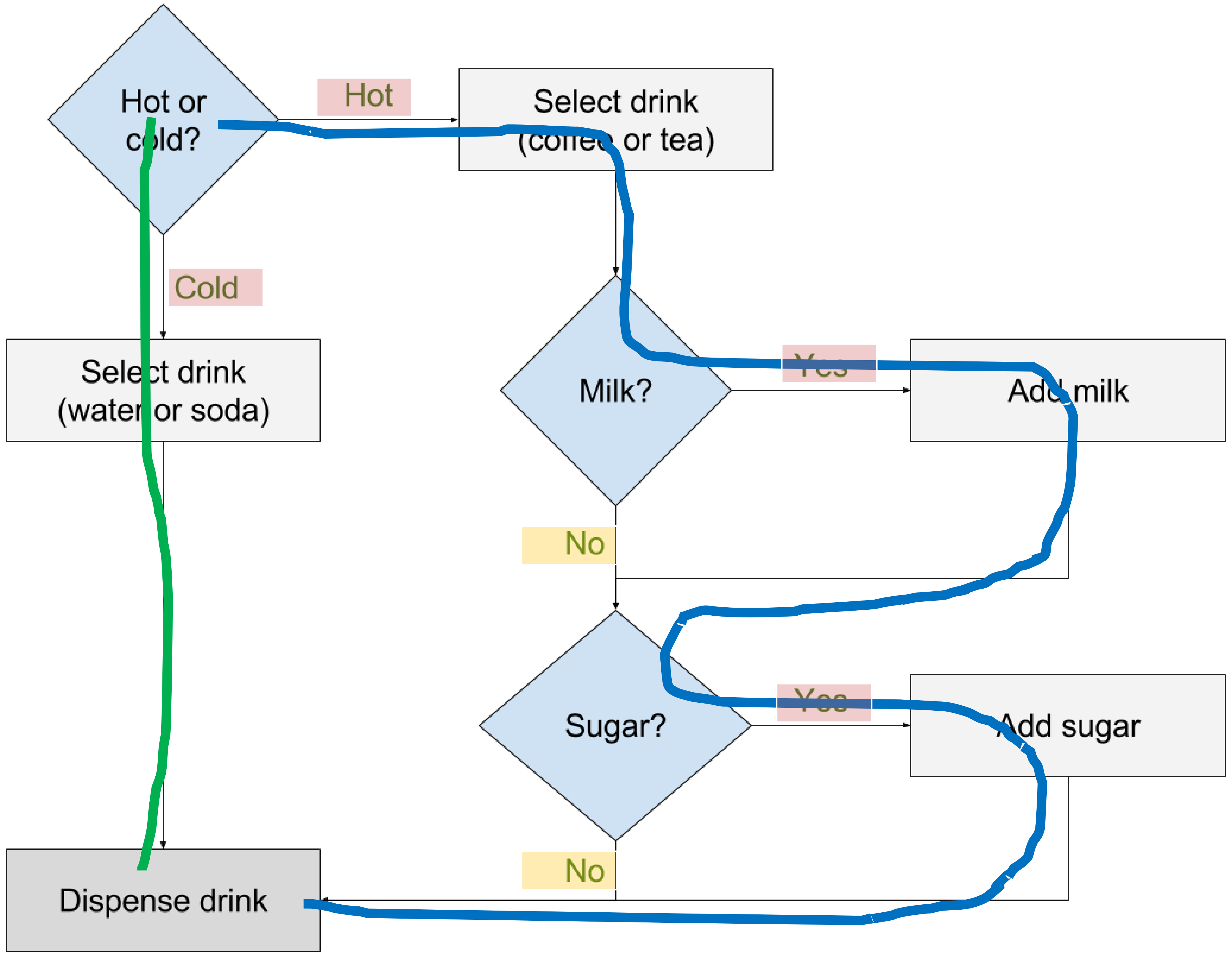
How many decision outcomes exercised?

Hot / Cold / Yes / No

4 decision outcomes exercised

Decision coverage

4 / 6 = 67 %



Exercise 3(c)

What additional tests would be needed to achieve 100% decision and statement coverage?

Exercise 3(c): Answer

What additional tests would be needed to achieve 100% decision and statement coverage?

Additional tests

Statement coverage:

No further tests

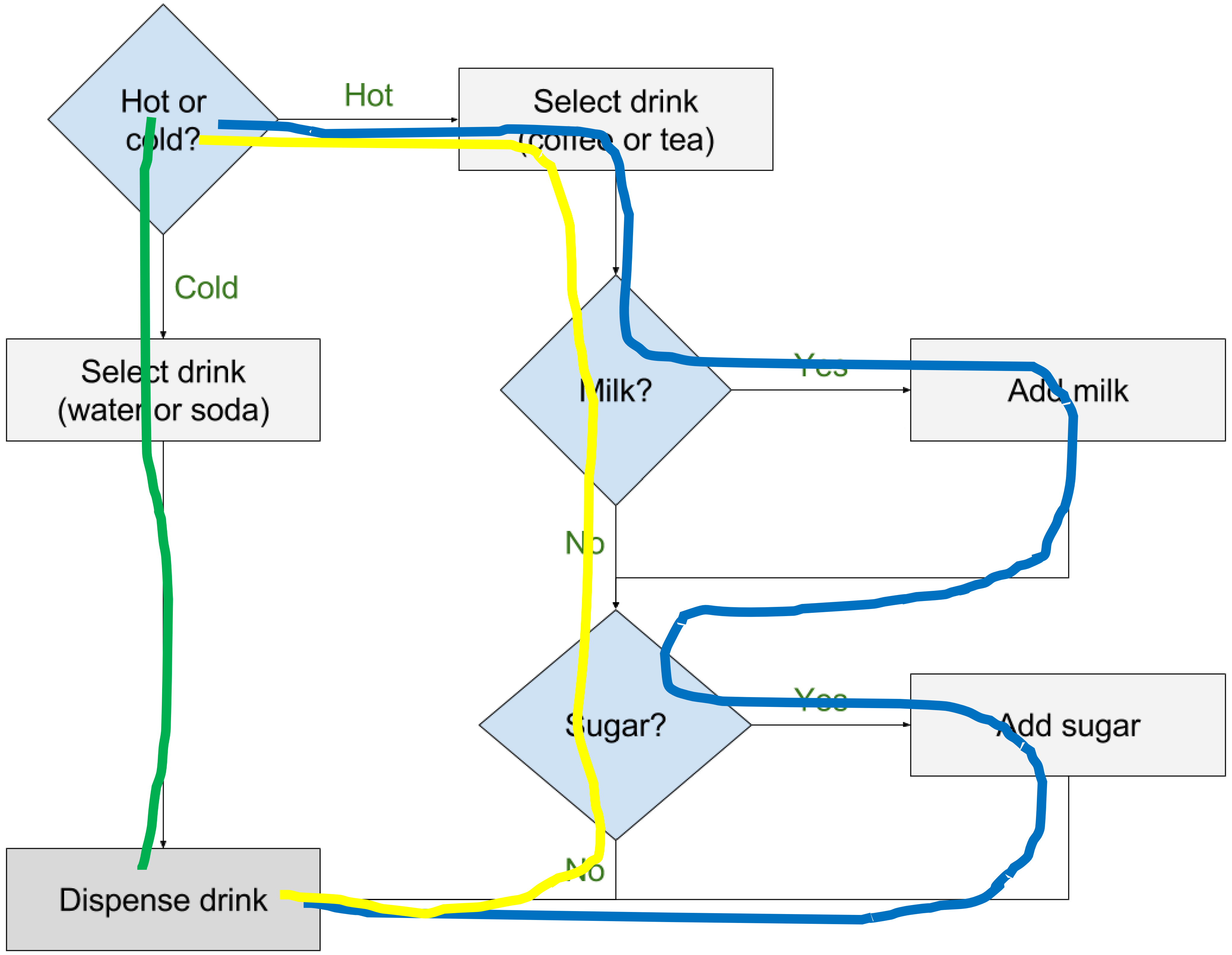
Decision coverage

Must exercise No / No

Test 3:

Hot drink, no milk, no sugar

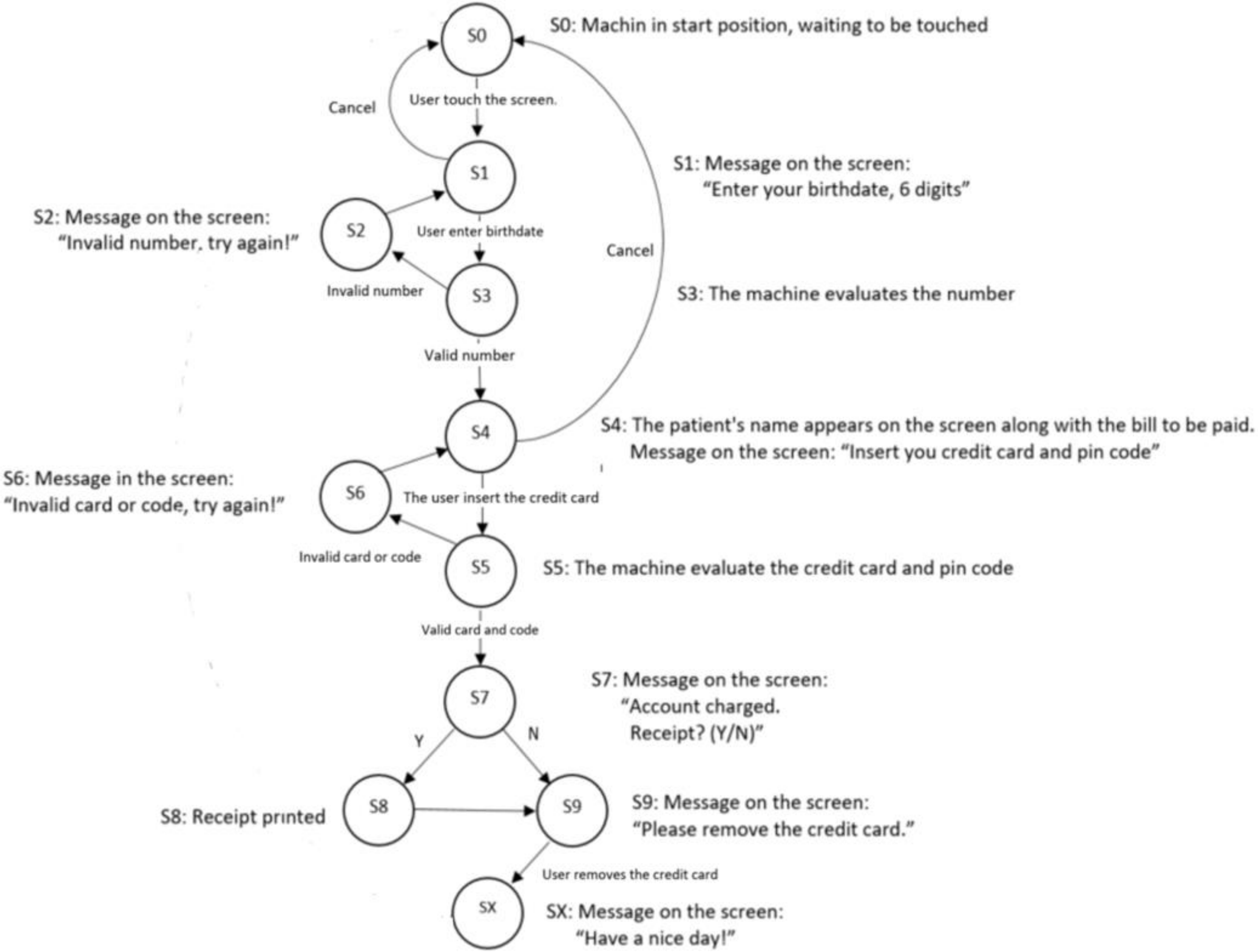
All decisions exercised



Exercise 4a – State transition: Previous exam

A medical center will install a payment machine for patients to pay for their medical consultations. Before starting to use the payment machine, the center wants to perform some user tests that you will help design.
On the next slide, you will find a state transition diagram that describes the payment machine as well as the interaction between the machine and the user.

NB! You shall not judge whether the state transition diagram is correct or not but base your answers on it as it is.



S0: Machin in start position, waiting to be touched

S1: Message on the screen:
"Enter your birthdate, 6 digits"

S2: Message on the screen:
"Invalid number, try again!"

S3: The machine evaluates the number

S4: The patient's name appears on the screen along with the bill to be paid.
Message on the screen: "Insert you credit card and pin code"

S6: Message in the screen:
"Invalid card or code, try again!"

S5: The machine evaluate the credit card and pin code

S7: Message on the screen:
"Account charged.
Receipt? (Y/N)"

S8: Receipt printed

S9: Message on the screen:
"Please remove the credit card."

SX: Message on the screen:
"Have a nice day!"

Exercise 4a – State transition: Previous exam

a) Based on the state transition diagram in the pdf document, you shall now set up a test case as a path (sequence of states) that describes *the main scenario*, i.e. a successful payment transaction.

What is *the state coverage* of this test case?
What is *the transition coverage* of this test case?

b) What is the highest *transition coverage* we can achieve in one single test case?
What is *the state coverage* of this test case?
What is *the transition coverage* of this test case?

Exercise 4a – State transition: Previous exam

c) How many test cases do we need to achieve 100% *transition coverage*?
What is *the state coverage* of this test case?
What is *the transition coverage* of this test case?

d) Find the *shortest path* from S0 to SX that visits *every state.*
What is *the state coverage* of this test case?
What is *the transition coverage* of this test case?

e) Why is 100% *state coverage* in most cases not enough as an *exit criterion* for testing?

Exercise 4b – Use case testing

Use the state transition diagram from exercise 4a to set up different use cases that describe the interactions between a user and the machine.

The slides are made by

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