Tutorial 4

Swinburne University of Technology

Software Testing and Reliability (SWE30009)

Semester 2, 2023

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Metamorphic testing

- Can work even if test oracle does not exist
- Makes use of an identified relation among multiple test cases

Metamorphic relations

- Metamorphic relations are **necessary properties** of the **algorithm** to be implemented, which involve **multiple** related inputs and their outputs

Necessary

- A is said to be necessary for a condition B

  if (and only if)

  the falsity of A
  guarantees the falsity of B

Property

- A cat
- A car
- A laptop
- An Australian

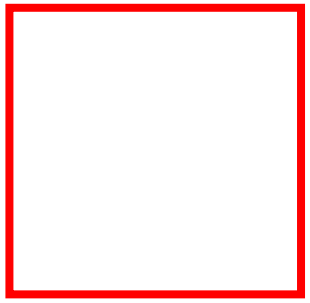
Sufficient

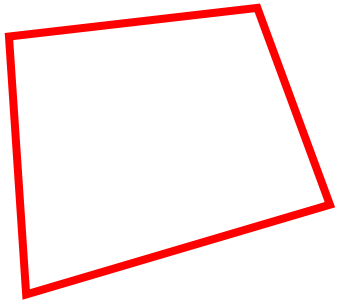
- A is said to be sufficient for a condition B

  if (and only if)

  the truth of A
  guarantees the truth of B

Neccesary versus sufficient





Neccesary property

A square has 4 sides

Question

Will a shape has 4 sides a square?

Sufficient property

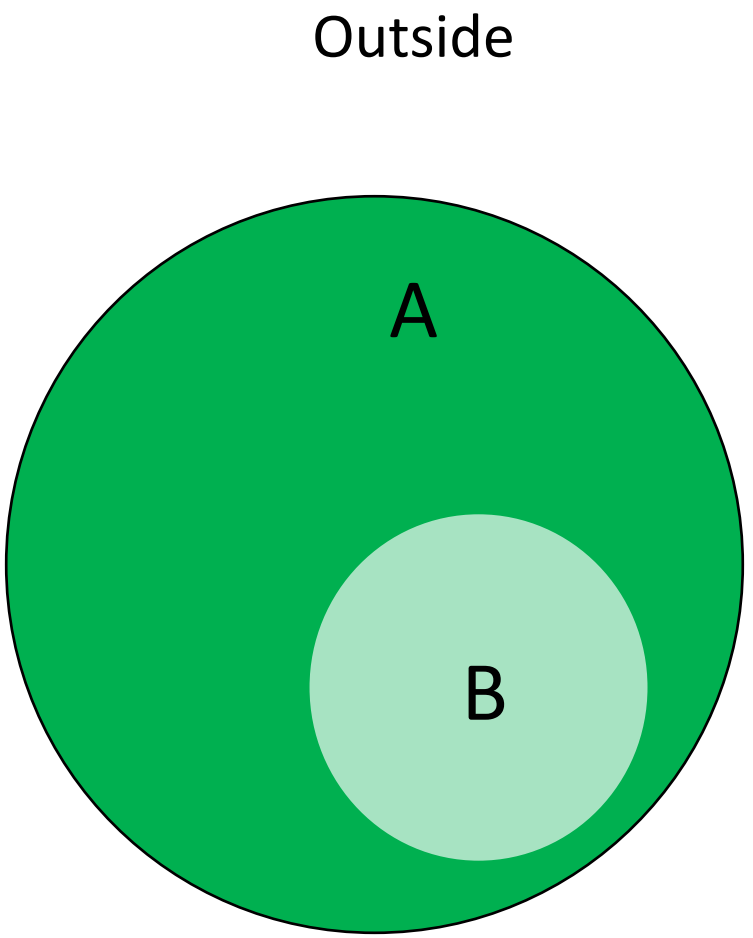
A shape with 4 sides of same lengths and 4 angles of 90 degree is a square

Relationship

A is neccesary for B

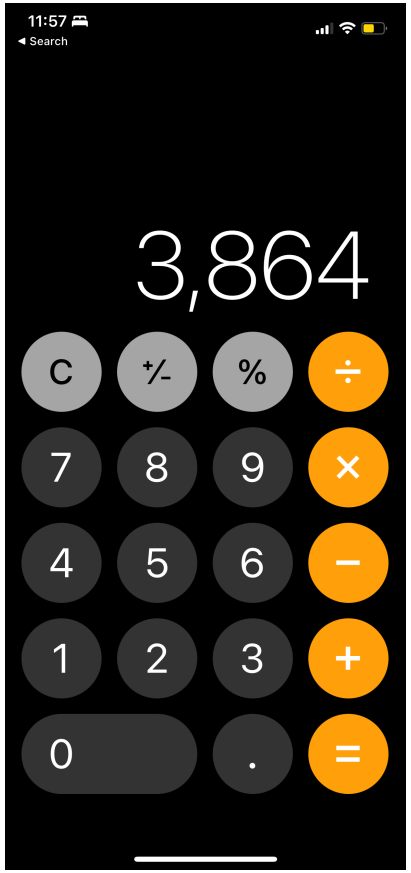
⇔

B is sufficient for A

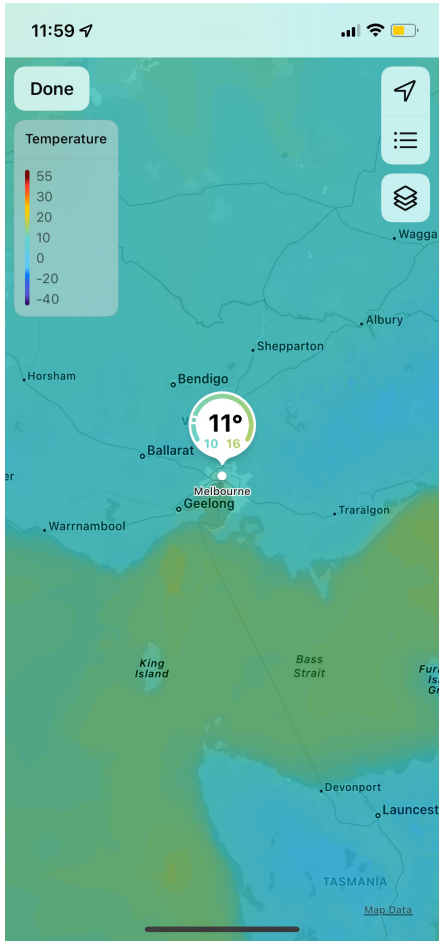


Discussions

Calculator App



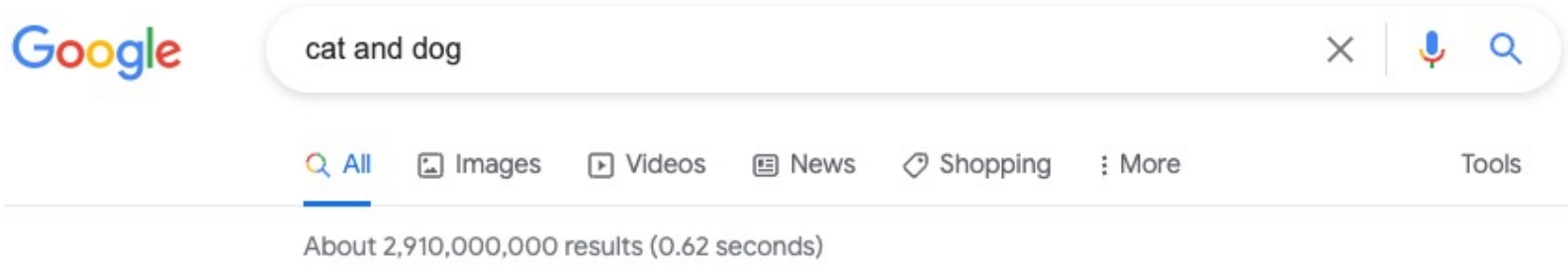
Weather App

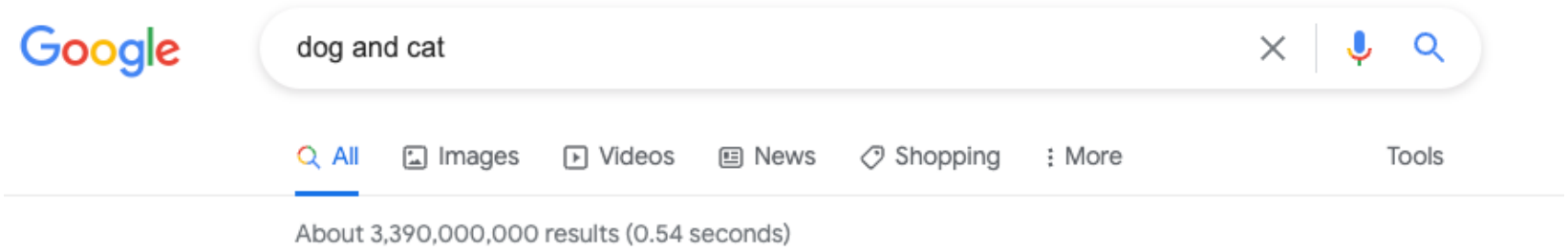


Vending machine

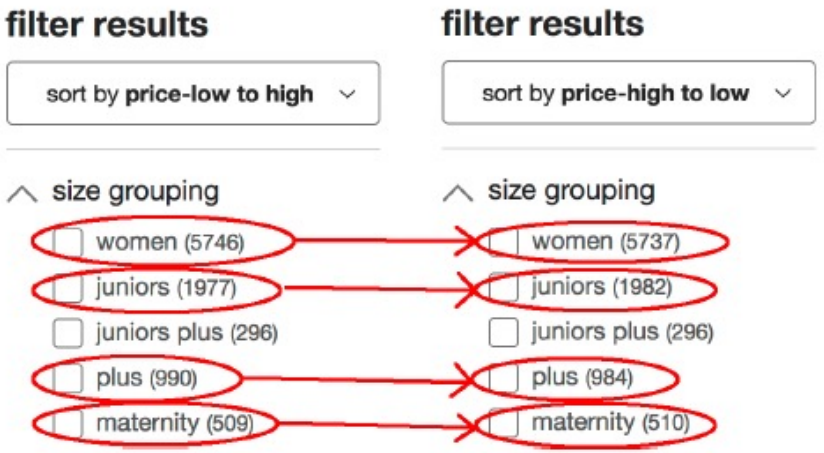
Source: https://www.selecta.com/int/en/products-and-solutions/vending-machines/cold-drinks-vending-machines

Metamorphic relation

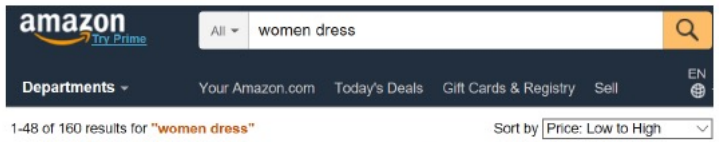




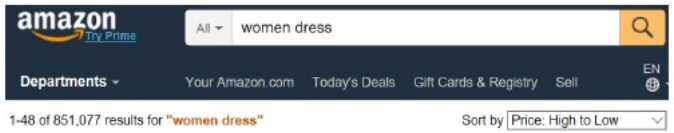
Metamorphic relation



(c) Inconsistent results identified by comparing the source (left) and follow-up (right) outputs using the MR, when searching for "women" in www.target.com.



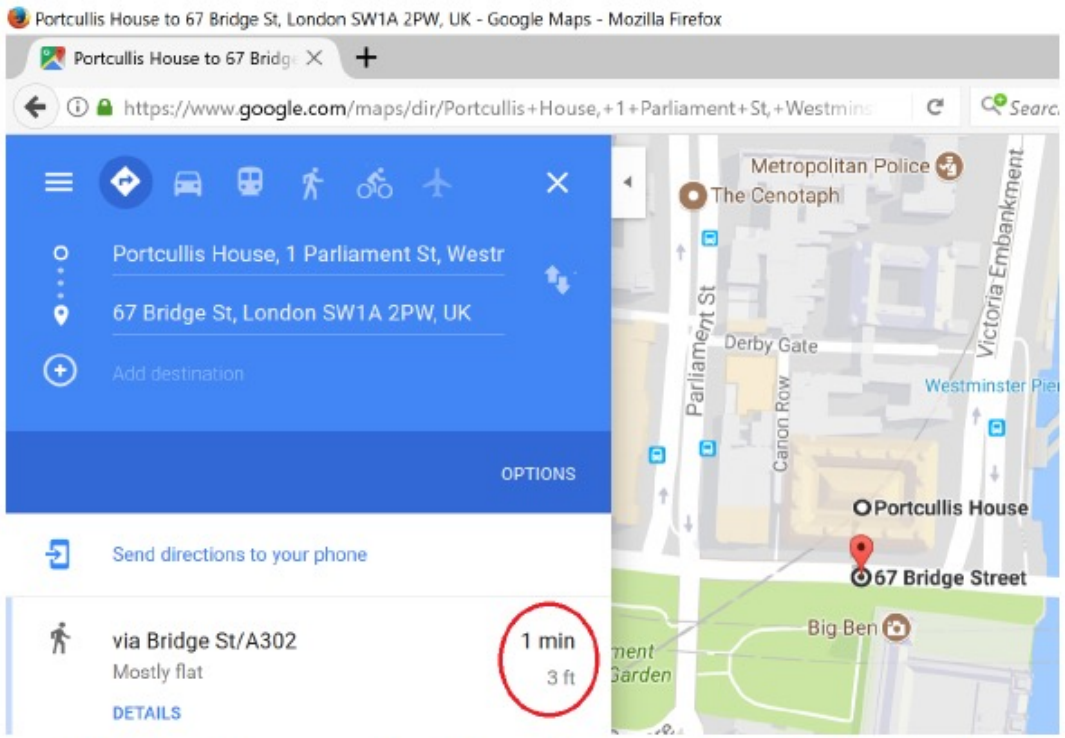
(a) A source query: search for "women dress" in www.amazon.com, sorted by price (low to high)—160 "most relevant" results.



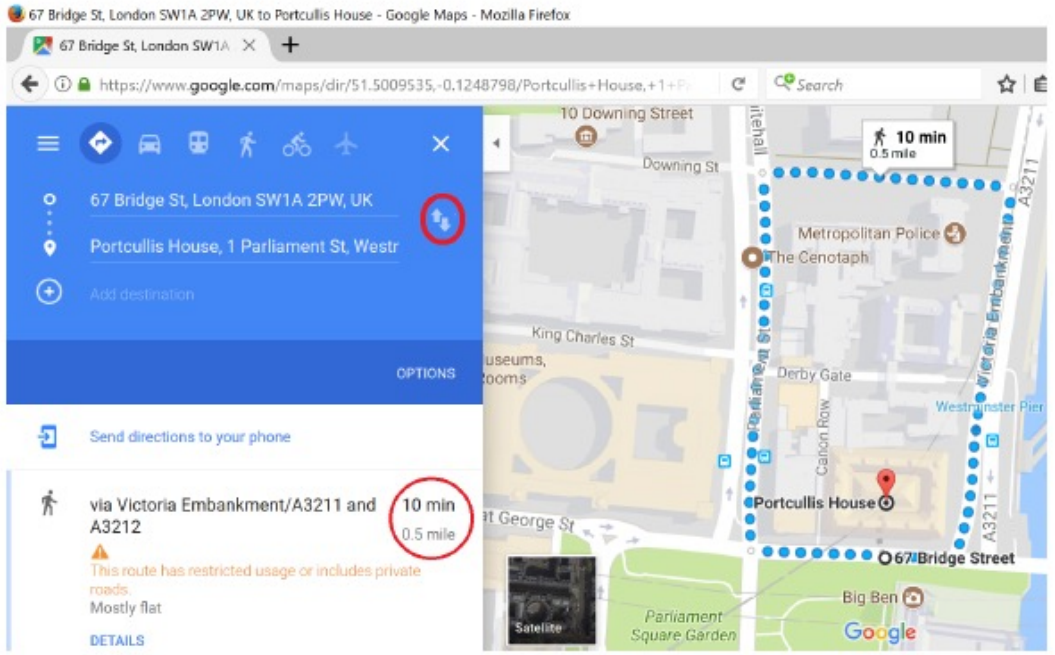
(b) A follow-up query: search for "women dress" in www.amazon.com, sorted by price (high to low)—851,077 "most relevant" results.

Zhou et al. (2018), IEEE Transactions on Software Engineering

Metamorphic relation



(a) Walking navigation in London: 3 ft, 1 min.



(b) Bad case detected: MR violation after reversing origin and destination: 0.5 miles, 10 min.

Zhou et al. (2018), IEEE Transactions on Software Engineering

Testing process

1

Identify a **metamorphic relation** (MR)

2

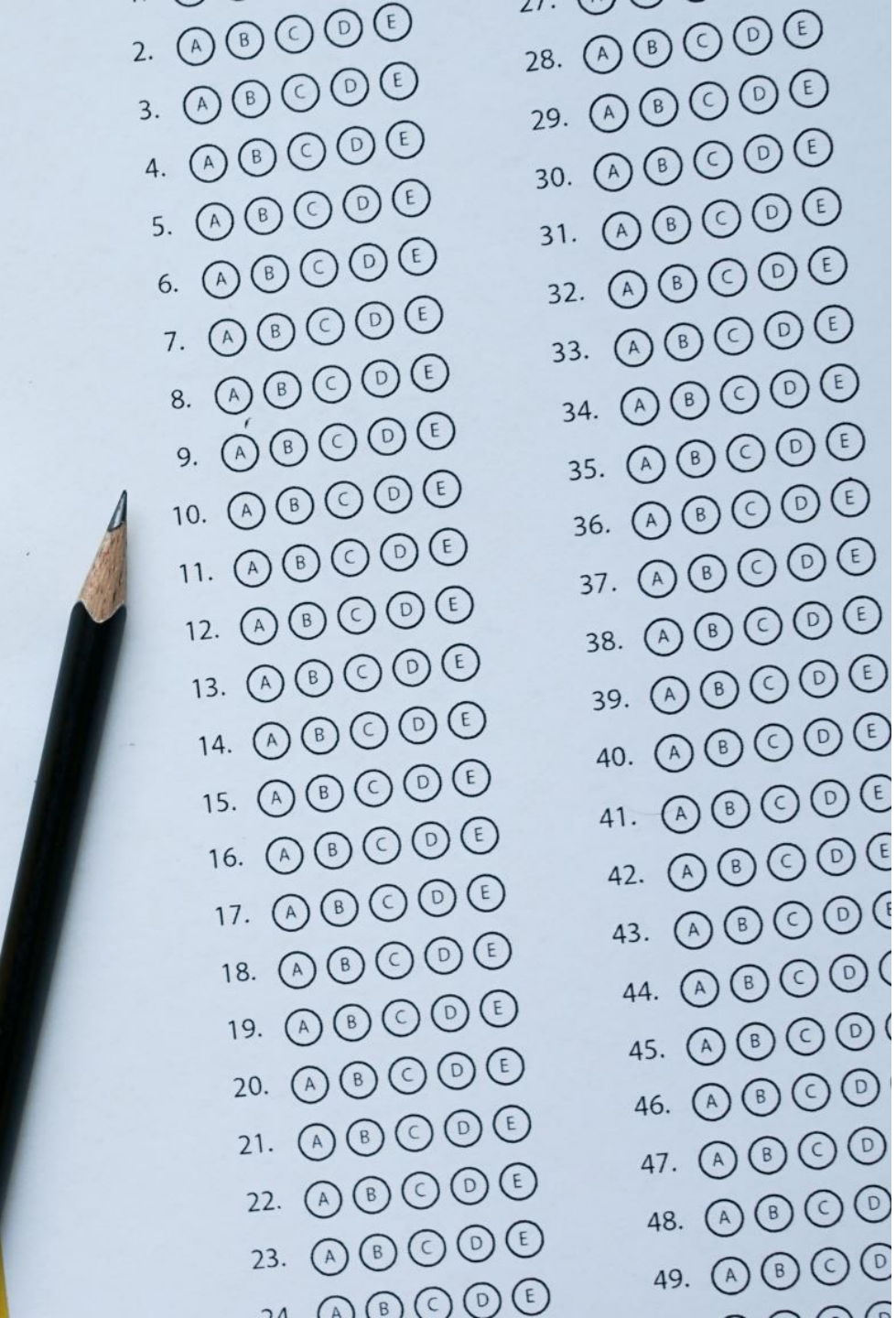
Define and execute **source test case(s)**

3

Construct and execute **follow-up test case(s)** using MR

4

Verify MR using both source and follow-up outputs (and if needed, the inputs)



Discussion

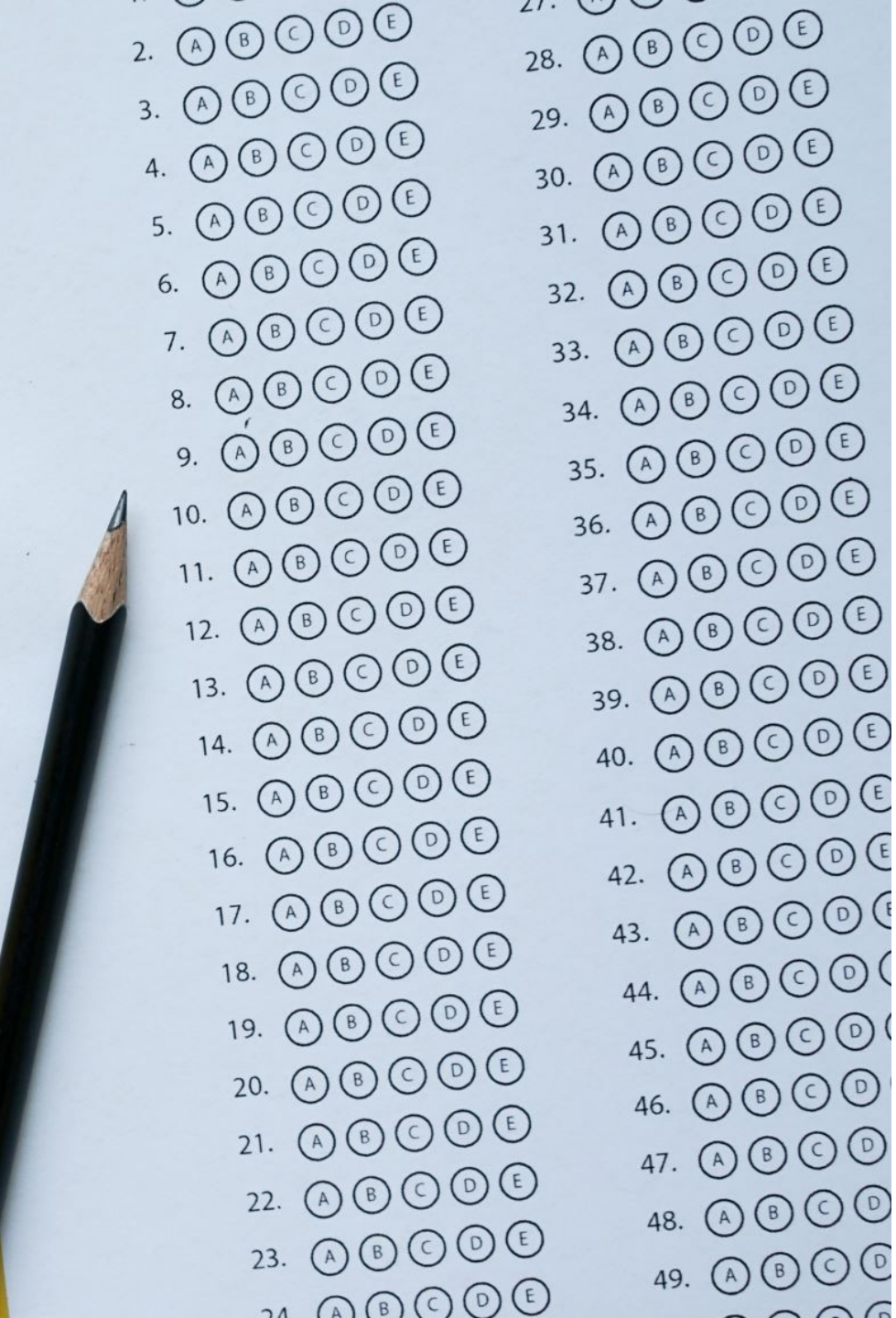
Propose your own MR to test program to compute the **product** of

Source input

[1, 8, 20, 22, 10]

Testing

1. MR: Swap orders of elements
2. Source test case(s)
   - Input(s): [1, 8, 20, 22, 10]
   - Output(s): 72100
3. Follow-up test case(s)
   - Input(s): [1, 8, 20, 10, 22]
   - Output(s): 35200
4. Verify MR: 72100=/=35200



Discussion

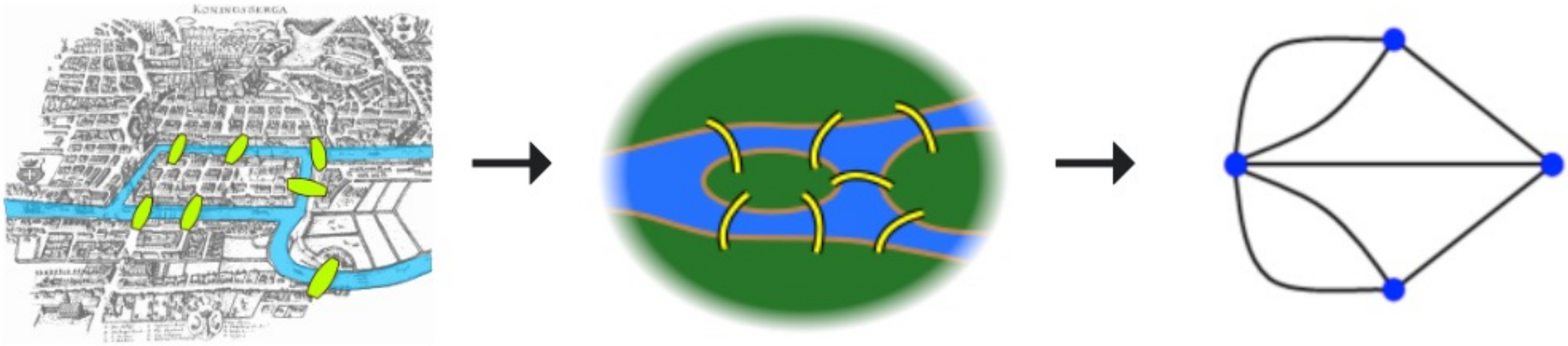
Propose your own MR to test program to compute the **sum** of

Source input

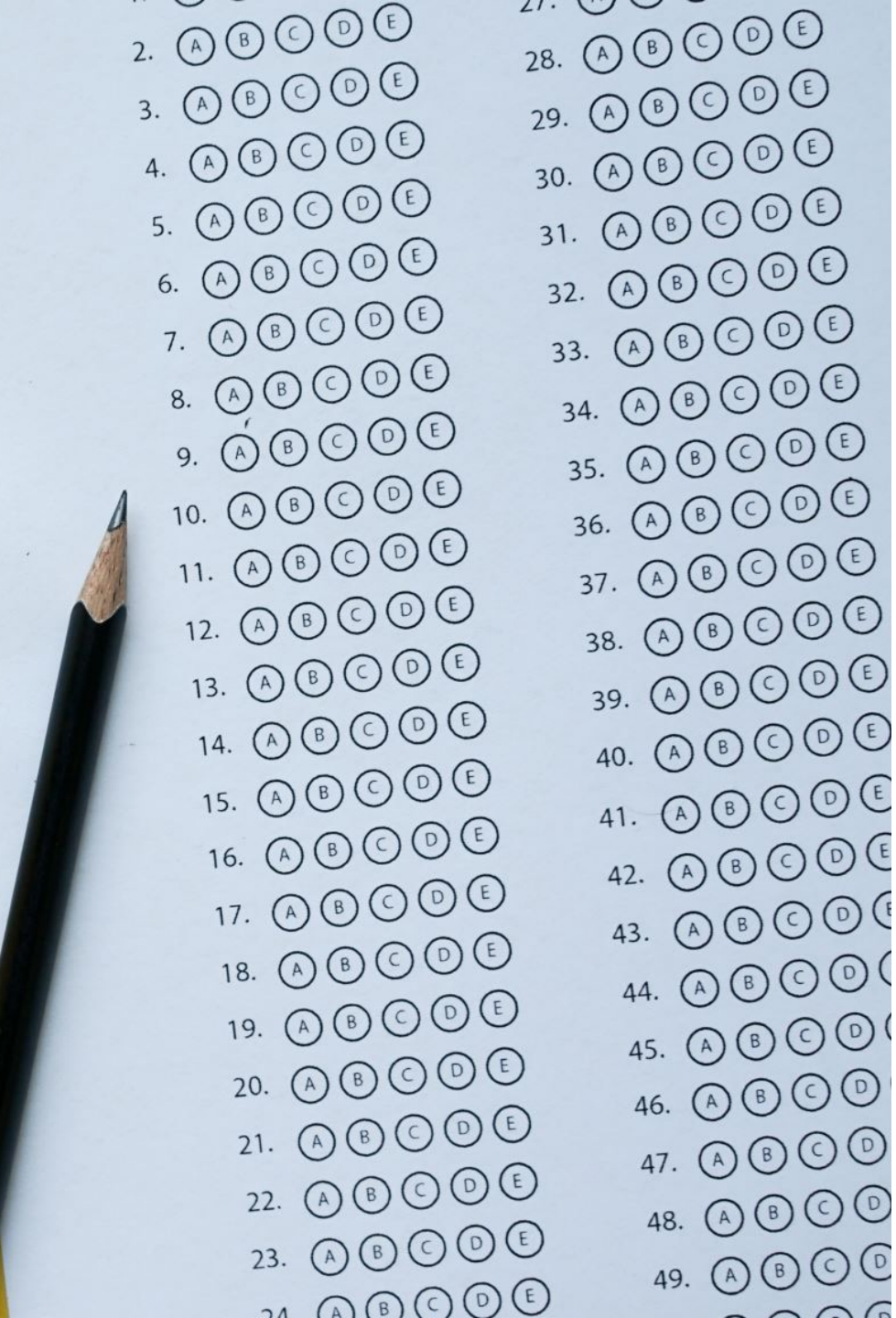
[1, 8, 20, 22, 10]

Königsberg Bridge

- Is there a way to devise a walk through the city that would cross each of those bridges once and only once?

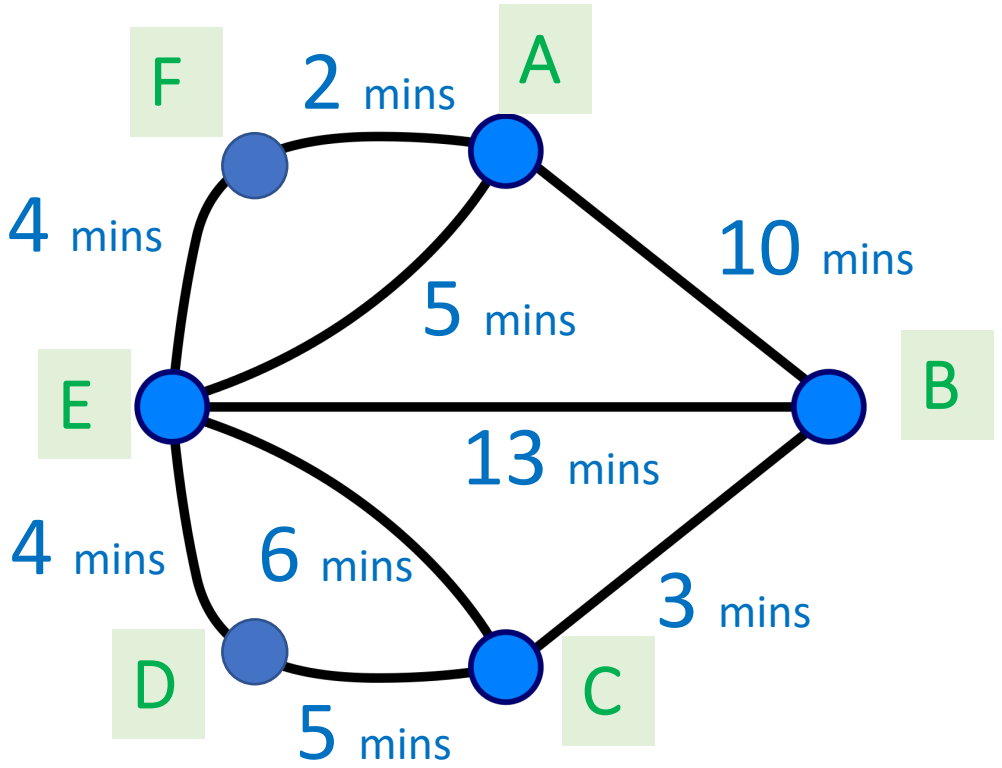


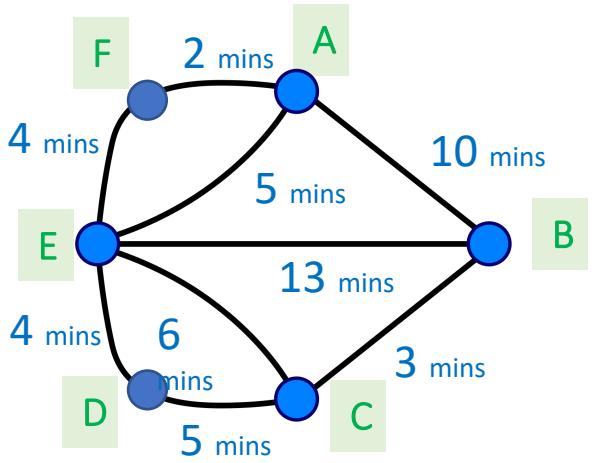
Source: https://en.wikipedia.org/wiki/Seven_Bridges_of_K%C3%B6nigsberg#/media/File:Konigsberg_bridges.png



Discussion

Propose your own MR to test program to compute the shortest route in a map





Testing

1. MR: dis(E,C) + dis(C,B) >= dis(E,B)
2. Source test cases
   - Inputs: (E,C) and (C,B)
   - Outputs: 6 and 3
3. Follow-up test case
   - Input: (E,B)
   - Output: 13
4. Verify MR: 6+3 < 13