# CISC/CMPE 327 Software Quality Assurance

Queen's University, 2019-fall

Lecture #11 Black Box Testing – Input Coverage

# Requirement

"Given as input two integers x and y, output all the positive numbers smaller than or equal to x that are evenly divisible by y. If either x or y is zero, then output zero."

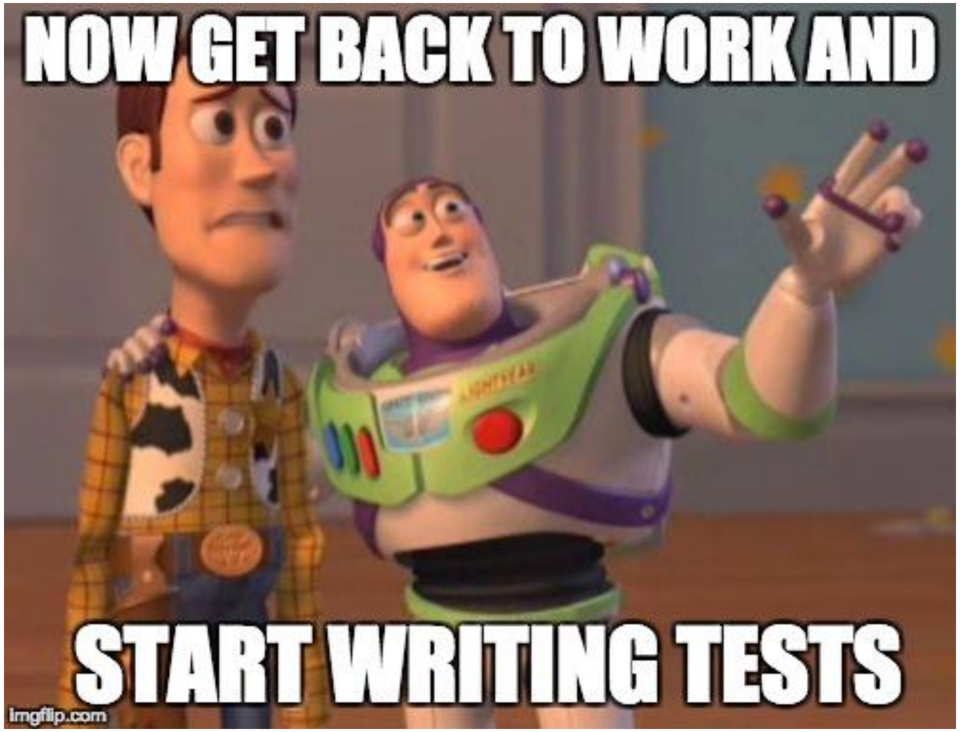
x: 10

y: 3

Output: ????

# Requirement

"Given as input two integers x and y, output all the positive numbers smaller than or equal to x that are evenly divisible by y. If either x or y is zero, then output zero."



# Requirements Partitioning

- "Given as input two integers x and y"
  - R1. Accept two integers as input.
- "output ... the numbers"
  - R2. Output zero or more (integer) numbers.
- "smaller than or equal to x"
  - R3. All numbers output must be less than or equal to the first input number.
- "evenly divisible by y"
  - R4. All numbers output must be evenly divisible by the second number.
- "all the numbers"
  - R5. Output must contain **all** numbers that meet both R3 and R4.
- "If either x or y is zero, then output zero."
  - R6. Output must be zero (only) in the case where either first or second input integer is zero.

# Black Box Testing

- Black Box Testing
  - Functionality Coverage
  - Input Coverage
  - Output Coverage

# What is 'input'

- All the possible inputs allowed by the functional specifications (requirements)

# Input Coverage Testing

- Input Coverage
  1. Analyze all the possible inputs
  2. Create test case based on the analysis

  Exhaustive, input partitioning, shotgun, (robustness) boundary

  - Objective: Show software correctly handles all allowed inputs

# Exhaustive Testing??

# Exhaustive Testing

- What does "all" mean?
  - Cover every possible input to the program
  - Yields a strong result
  - Easy system for test cases, obvious when done

# Exhaustive Testing

- Requirement: "return the logical AND operation of two Boolean inputs"

# Exhaustive Testing

- Requirement: "return the logical AND operation of two Boolean inputs"

| | | |
|---|---|---|
| C1. | false | false |
| C2. | true | false |
| C3. | false | true |
| C4. | true | true |

# Exhaustive Testing

"Given as input two integers x and y, output all the positive numbers smaller than or equal to x that are evenly divisible by y. If either x or y is zero, then output zero."

# Exhaustive Testing

"Given as input two integers x and y, output all the positive numbers smaller than or equal to x that are evenly divisible by y. If either x or y is zero, then output zero."

- Assume that each integer has 32 bits, there are still more than
- 16,000,000,000,000,000,000 pairs to test

# Input Partition Testing

- Exhaustive Testing - Practical? **extremely** rare
- Partition all the possible inputs into equivalence classes
  - Share with something in common

# Input Partition Testing

"Given as input two integers x and y, output all the positive numbers smaller than or equal to x that are evenly divisible by y. If either x or y is zero, then output zero."

# Input Partition Testing

"Given as input two integers x and y, output all the positive numbers smaller than or equal to x that are evenly divisible by y. If either x or y is zero, then output zero."

| Partition | x input | y input |
|---|---|---|
| P1 | 0 | nonzero |
| P2 | nonzero | 0 |
| P3 | 0 | 0 |
| P4 | less than zero | less than zero |
| P5 | less than zero | greater than zero |
| P6 | greater than zero | less than zero |
| P7 | greater than zero | greater than zero |

# Input Partition Testing

- Covering Partitions
  - simplest input values
  - vary them as little as possible

# Input Partition Testing

- Covering Partitions

| Partition | x partition | y partition | x input | y input |
|---|---|---|---|---|
| P1 | 0 | nonzero | **0** | **1** |
| P2 | nonzero | 0 | **1** | **0** |
| P3 | 0 | 0 | **0** | **0** |
| P4 | less than zero | less than zero | **-1** | **-1** |
| P5 | less than zero | greater than zero | **-1** | **1** |
| P6 | greater than zero | less than zero | **1** | **-1** |
| P7 | greater than zero | greater than zero | **1** | **1** |

# Input Partition Testing

- Covering Partitions

| Partition | x partition | y partition | x input | y input |
|---|---|---|---|---|
| P1 | 0 | nonzero | **0** | **1** |
| P2 | nonzero | 0 | **1** | **0** |
| P3 | 0 | 0 | **0** | **0** |
| P4 | less than zero | less than zero | **-1** | **-1** |
| P5 | less than zero | greater than zero | **-1** | **1** |
| P6 | greater than zero | less than zero | **1** | **-1** |
| P7 | greater than zero | greater than zero | **1** | **1** |

**Do not take into account the intention or actions of the program, only that it handles all its input classes**

# Catching Errors in Requirements

- Systematically partitioning
  - Find/fix missing requirements

- Systematic creation of tests from different points of view
  - Expose problems in the software
  - Expose problems in specification
  - A way to 'test' requirement before running actual text

# Advantages of Input Partition Testing

- intuitively for testing
  - Different response to each kind of input
- straightforward to identify a set of partitions

- We know when we are done:

# Advantages of Input Partition Testing

- intuitively for testing
  - Different response to each kind of input
- straightforward to identify a set of partitions

- We know when we are done:
  - Partition coverage

- Program can at least handle one example of each different kind of input correctly

# Black Box Shotgun Testing

- Black box shotgun testing consists of
  - choosing random input values Repeat for a large number of times
  - Verify outputs and observe crashes
- Practically, legal set and illegal set as separate sets of shotgun tests

| Test | x input | y input |
|---|---|---|
| T1 | 682 | 27631 |
| T2 | -89 | 5244 |
| T3 | 7368279 | -82763 |

and so on..

# Shotgun Testing: Systematic?

- Partition? Coverage?
- Completion?
- Require a very large number of test cases
- Automated verification?

# Input Partition + Shotgun Testing

- A Hybrid Method
  - shotgun method to choose random input within each partition
  - additional confidence:
    - simple input values 👍
    - random value 👍
  - Difficulties:
    - automated output verification to be practical
    - simple input first -> then shotgun

# Input Partition + Shotgun Testing

- A Hybrid Method

# Input Robustness Testing

- Robustness is the property that a program doesn't crash or halt unexpectedly, no matter what the input

- Robustness testing tests for this property
  1. Shotgun robustness testing
  2. Boundary value robustness testing

# Input Boundary Testing

- Boundary Values
  - typical failures come at the boundaries of the legal or expected range of values
  - Example (exercise): reverse a linked list!

# Input Boundary Testing

- Boundary Values
  - black box testers often create boundary value (edge cases)
  - Boundary value testing is a systematic test method
    - An easy way to choose test cases,
    - an easy way to know when we are done
      - when all boundary tested?

# Summary

- Black Box Testing
  - Input coverage methods analyze the set of possible inputs specified and create tests to cover them
  - Exhaustive testing is usually impractical, but we can approximate it using input partitioning
  - Shotgun testing can be added to input partitioning to give additional confidence
  - Robustness testing checks for crashes on unexpected or unusual input, such as the boundaries of the input range

# Next Time

- More black box testing:
  **output** coverage methods