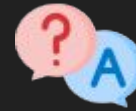


SEMINAR: Kiểm Tra Tính Đúng Đắn và Hiệu Năng của Chương Trình bằng Bộ Test

Nguyễn Trung Hiếu, Nguyễn Quốc Cường, Võ Linh Bảo



1. Test planning
2. 4 levels of testing
3. Writing test cases
4. Examples



WHY TESTING ???



Caution: human error



Requirements



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How Fast Is Your Code? Big O Notation

$O(1)$

$O(\log n)$

$O(n)$

$O(n \log n)$

$O(n^2)$

$O(2^n)$

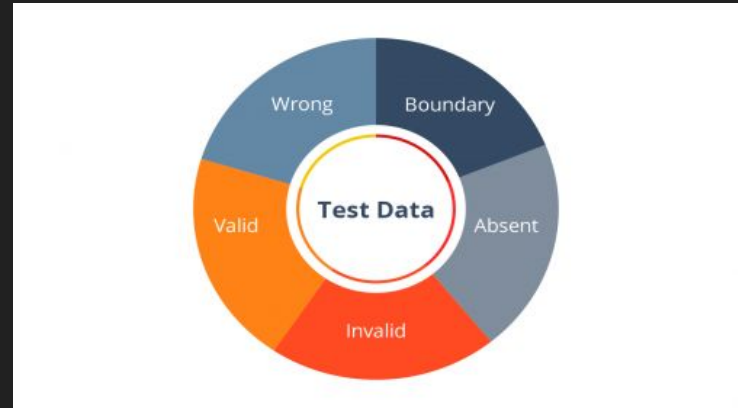
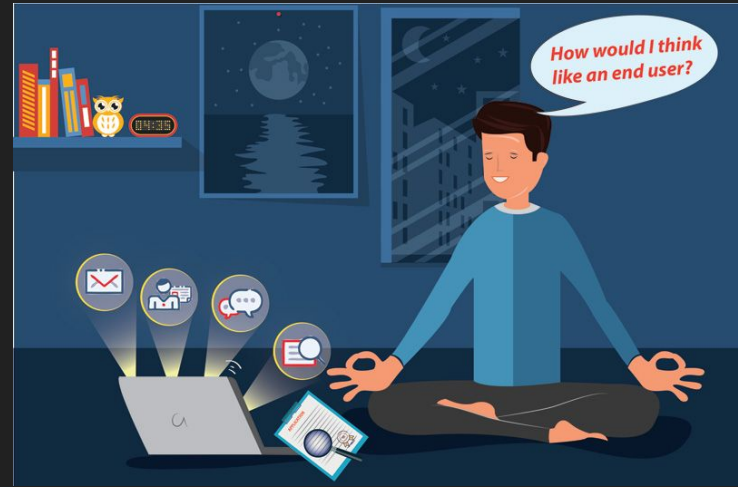
$O(n^n)$

TEST PLANNING

Before testing:

1. Which level of testing?
2. Test case design
each scenario, figure out (**what is expected for each case in scenario**):
 - a. How fast?
 - b. Hardware specialization?
 - c. Expected response?
3. Prepare test data?

For



4 Levels of Testing



1	Unit Testing	Done by Developers	Simple, test small part of project
2	Integration Testing	Done by Testers	Test combination of code modules
3	System Testing	Done by Testers	Test the whole system
4	Acceptance Testing	Done by End Users	User experience

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We will be practicing the the simplest, yet the most important kind of test: Unit Testing!



UNIT TEST

- When coding, **usually helpful** to quickly test after finishing a small part.
- Can be very similar to testing in competitive programming
- Need an effective **test case generation plan**



CP EXAMPLE

Problem: Write a function $f(x)$ to print series numbers of days in a month given a sequence of months. Return -1 if not a month is entered.

Example test cases:

Test 1: "May September"
Expected: 31 30
(**normal test**)

Test 2: "May ... (x 1 billion) ... May"
Expected: 31 ... (x 1 billion) ... 31
(**boundary test**)

Test 3: "Detemper"
Expected: -1
(**abnormal test**)





TEST CASE GENERATING PLAN

Design step: determine

- Test scenario
- For each possible test case:
 - *Testing goal (correctness, performance)*
 - *Pre-condition and post-condition*
 - *Test case format*
 - *Test steps*

Preparing step: making test case's data



WHAT ARE GOOD TEST CASES?

- **Cover everything: speed, correctness, upper/lower boundary, abnormal cases**
- **Simple and clear**
- **Don't repeat itself**
- **Each test case needs an id/name**
- **Always return the same result for a piece of code**
- **Need to be review by many people**

Built-Operation-Transfer (BOT)

BOT summary¹ : Công ty Modern Highway chia con đường thành n đoạn ($1 \leq n \leq 10^6$), lãi thu được ở đoạn đường thứ i là a_i ($0 \leq |a_i| \leq 10^9$, $i = 1 \div n$). Chọn ra p tới q trong n đoạn đường trên sao cho công ty Modern Highway ít bị lỗ nhất (lời nhiều nhất)

INPUT	OUTPUT
16 2 -4 5 -8 4 -1 -1 1 1 1 -2 2 4 -6 9 -4	5 15 12

¹Please view the full problem description at: https://khmt.uit.edu.vn/laptrinh/cs112-2021/view_problem/1

BOT PROBLEM TEST GENERATING

- Test scenario: CP problem
- Possible test case:

NORMAL

INPUT	OUTPUT
16 2 -4 5 -8 4 -1 -1 1 1 1 -2 2 4 -6 9 -4	5 15 12
4 -1 2 4 2 1	2 3 2 1

BOT PROBLEM TEST GENERATING

- Test scenario: CP problem
- Possible test case:

ABNORMAL

INPUT	OUTPUT
4 1 2 3 4	1 2 3 4
4 -1 -2 -4 -2 -1	-1
5 1 2 -10 2 1	1 2
5 1 2 3 -1 1	1 2 3

BOT PROBLEM TEST GENERATING

- Test scenario: CP problem
- Possible test case:

BOUNDARY

INPUT	OUTPUT
1000000 1 1 1 ... 3	1 1 1 ... 3
1000000 1000000000 1000000000 ... 1000000000	1000000000 1000000000 ... 1000000000

BOT PROBLEM TEST GENERATING

Goal : CORRECTNESS

Test format

INPUT	EXPECTED OUTPUT	ACTUAL OUTPUT	RESULT
1000000 1 1 1 ... 3	1 1 1 ... 3	1 1 1 ... 3	PASS
5 1 2 3 -1 1	1 2 3	1 2 3 -1 1	FAILED

BOT PROBLEM TEST GENERATING

Goal : PERFORMANCE

Test format

INPUT	EXPECTED TIME	ACTUAL TIME	RESULT
1000000 1 1 1 ... 3	< 1s	0.94s	PASS
5 1 2 3 -1 1	< 1s	1.57s	FAILED



LOOP OVER ALL TEST CASE, RUN CODE AND GET ACTUAL RESULT, COMPARE TO THE EXPECTED ONE

TEST SCENARIO OF WE CODE



WE CODE WEBSITE

Username

Password

[Register](#) | [Reset Password](#) [Login](#)

Calendar

January 2021

Mon	Tue	Wed	Thu	Fri	Sat	Sun
28	29	30	31	1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

...

submit	Final	ID	Problem	Submit Time	Score	Delay %	Language	Status	Code
✓	401		WaterSupply	2020-09-20 14:01:08	1	No Delay 100%	Python 3	1	Code
0	402		WaterSupply	2020-09-20 13:58:15	1	No Delay 100%	Python 3	1	Code
0	403		WaterSupply	2020-09-20 13:56:04	1	No Delay 100%	Python 3	1	Code
0	404		WaterSupply	2020-09-20 13:55:21	0	No Delay 100%	Python 3	1	Code

#	Username	Name	Index 1	WaterSupply 1	Total 2	Total accepted
1	n007	CS112211047N1-Mobin 1	1	1	2	2
2	n011	CS112211047N1-Mobin 1	1	1	2	2
3	n008	Index 1	1	1	2	2
4	n004	CS112211047N1-Mobin 1	1	1	2	2
5	n002	CS112211047N1-Mobin 1	1	1	2	2
6	n005	Index 1	1	1	2	2
7	18520748	Nguyễn Quang Hùng	1	1	2	2

























Test login form

Test calendar

Test submission history

Test score board

POSSIBLE TEST CASE





Final	submit ID	Problem	Submit Time	Score	Delay %	Language	Status	Code
	44		2020-09-15 13:34:55	1	No Delay 100%	Python 3		
	43		2020-09-15 13:33:44	0	No Delay 100%	Python 3		
	11		2020-09-12 20:53:43	1	No Delay 100%	Python 3		
	10		2020-09-12 20:44:34	1	No Delay 100%	Python 3		
	3		2020-09-10 15:08:30	1	No Delay 100%	Python 3		
	2		2020-09-10 15:07:00	1	No Delay 100%	Python 3		

Submission is:

- Wrong answer
- Time limit exceeded
- Memory limit exceeded
- Runtime Error
- Compilation Error
- Accepted

EXAMPLE: CASE ACCEPTED

- Goal : correctness
- Pre - condition: browser, softwares were all installed
- Post - condition: Result of submission would be saved into log
- Test format:

INPUT	EXPECTED OUTPUT	ACTUAL OUTPUT	RESULT
(An accepted code)			PASS
(An accepted code)			FAILED

Exercise 1: Write test cases to the problem below

Salary Problem summary¹: A restaurant has n workers, corresponding to n salaries. The boss wants to make all salaries equal using only the following operation: at a time, choose a worker, keep the chosen worker salary the same and increase the others' salaries by 1. Write a program to output the minimum number of operations he can use to equalize his men's salaries.

INPUT	OUTPUT
2	3
3	0
1 2 3	
2	
42 42	

¹Read the full problem description here: <https://www.codechef.com/problems/SALARY>

Exercise 2: Write test cases to the problem below

H-Index summary¹: Một bài báo có điểm số trích dẫn là c nếu nó được trích dẫn c lần. H-index là số k lớn nhất nếu một nhà khoa học có k bài báo được trích dẫn không dưới k lần. Viết chương trình tính H-index của một nhà khoa học khi biết điểm số trích dẫn c của n bài báo của nhà khoa học đó.

Constraints: $(1 \leq n \leq 5 \times 10^5)$, $(0 \leq c_i \leq 10^6, i = 1 \div n)$

INPUT	OUTPUT
5 8 5 3 4 10	4

¹Read the full problem description here: https://khmt.uit.edu.vn/laptrinh/cs112-2021/view_problem/3

Exercise 3: Write test cases to the problem below

Shortest Common Supersequence¹: Given two strings str1 and str2, return the shortest string that has both str1 and str2 as subsequences. If multiple answers exist, you may return any of them.

Constraints: $1 \leq \text{str1.length}, \text{str2.length} \leq 1000$, All lowercase English letter

INPUT	OUTPUT
abac cab	cabac

¹Read the full problem description here: <https://leetcode.com/problems/shortest-common-supersequence/>