Testing Techniques Applied to Virt Devel

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Agenda

- Software Testing Basics
- Equivalence Partitioning
- Boundary Value Analysis
- Combinatorial Testing

Glenford J. Myers' Triangle Check

- Input: 3 lengths of the triangle's sides
- Output: the triangle classification
  - Equilateral
  - Isoceles
  - Scalene
- How hard can it be to write a comprehensive set of test cases?

Triangle Check Basic Test Cases

Input	Expected Outcome
1, 1, 1	Equilateral
2, 2, 3	Isoceles
3, 4, 5	Scalene

```python
def triangle_check(a, b, c):
    if a == b == c:
        return "equilateral"
    elif a != b != c:
        return "scalene"
    else:
        return "isoceles"
```

```
class Triangle(Test):
    def test_equilateral(self):
        self.assertEqual(triangle_check(1, 1, 1),
                         "equilateral")

    def test_isoceles(self):
        self.assertEqual(triangle_check(2, 2, 3),
                         "isoceles")

    def test_scalene(self):
        self.assertEqual(triangle_check(3, 4, 5),
                         "scalene")
```

Triangle Check Error Test Cases

Input	Expected Outcome
0, 1, 1	Error
-1, 1, 1	Error
1, 1, 2	Error (not isoceles)
1, 2, 3	Error (not scalene)

Triangle Check Extended Test Cases

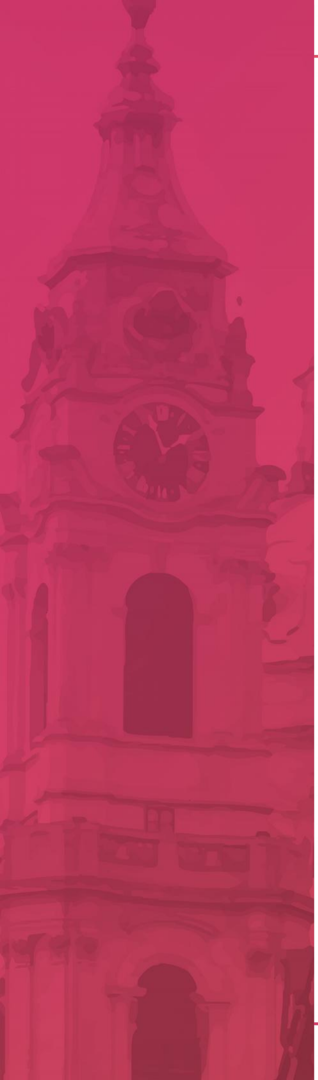
- Permutations of lengths order
  - “(A + B) <= C” .vs. “(C + B) <= A”
- Input is not a number
  - Give me a side with length “π”
- More or less than 3 input values
  - AKA “what do you mean by *triangles* ***must*** *have three sides*?”

Lessons from a simple example

- Even experienced developers will only think of a subset of those test cases
- Most software is not that simple
- Choosing good input data is key
  - Some input can be no better than other input already being used
  - Not all input are created equal, some will have a better shot at finding issues
  - We'll explore some techniques next

Equivalence Partitioning

- Don’t let the name scare you
- Think of groups of input that **should** generate similar **outcome**
  - A good pick is worth at least other two individual inputs
  - It usually tells us about what would happen (errors?) when values above or beyond itself would be used



```
// snippets from qemu/hw/acpi/cpu_hotplug.c

/* The current AML generator can cover the APIC ID range [0..255],
 * inclusive, for VCPU hotplug. */
 QEMU_BUILD_BUG_ON(ACPI_CPU_HOTPLUG_ID_LIMIT > 256);

...

if (pcms->apic_id_limit > ACPI_CPU_HOTPLUG_ID_LIMIT) {
    error_report("max_cpus is too large. APIC ID of last CPU is %u",
                 pcms->apic_id_limit - 1);
    exit(1);
}
```

Input Classes - # of CPUs

Invalid (smaller than minimum required)	Valid	Invalid
0	1 256	257

Input Classes – CPU IDs

Invalid (smaller than minimum required)	Valid	Invalid
-1	0 255	256

Boundary Analysis

- Also not scary
- When input classes are ordered, you can easily spot them
- These values are usually very good bets for tests

```
// snippets from tp-qemu/qemu/tests/cfg/cpu_add.cfg
    smp = 4
    vcpu_maxcpus = 255
    Variants:
        - cpuid_outof_range:
            cpuid_hotplug_vcpu0 = 256
            qmp_error_recheck = Unable to add CPU:.*, max allowed:.*
        - invalid_vcpuid:
            cpuid_hotplug_vcpu0 = -1
            qmp_error_recheck = Invalid parameter type.*, expected:.*
        - cpuid_already_exist:
            cpuid_hotplug_vcpu0 = 1
            qmp_error_recheck = Unable to add CPU:.*, it already exists
```

qemu-img bench

- “Run a simple sequential I/O benchmark on the specified image.”
- “A total number of **count** I/O requests is performed”

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Number of I/O requests - Actual

Invalid (smaller than minimum required)	Valid		Invalid (larger than maximum allowed)
-1	0	INT_MAX	INT_MAX + 1

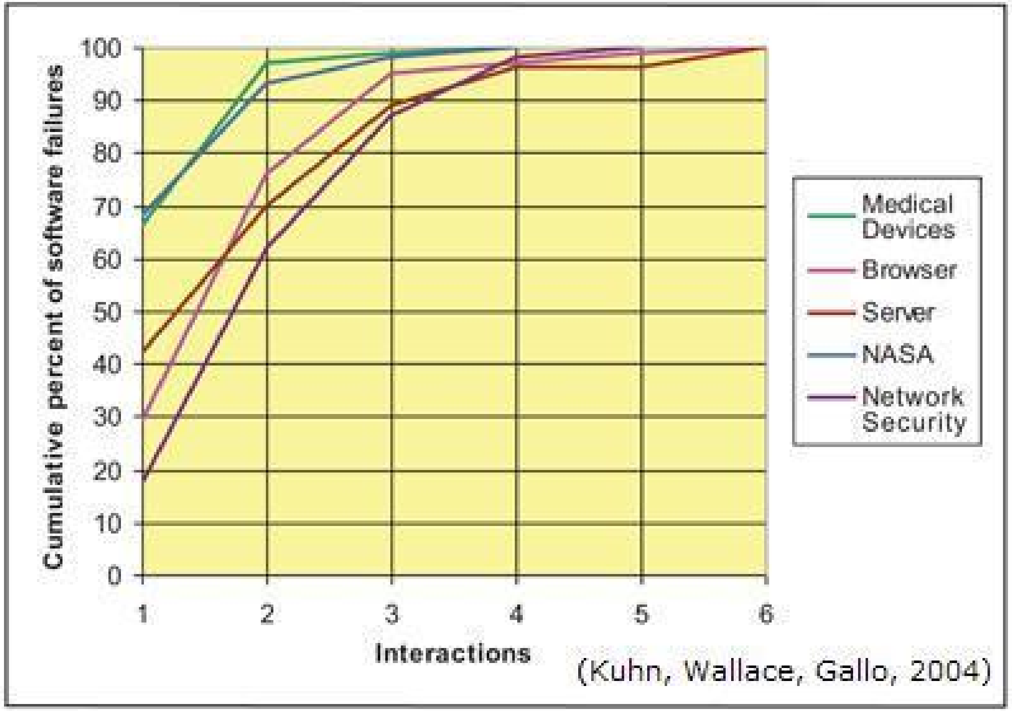
Number of I/O requests - Suggested

Invalid (smaller than minimum required)	Valid	Invalid (larger than maximum allowed)
0	1 .. UINT_MAX	UINT_MAX + 1

Combinatorial Testing

- Also known as “pair-wise”
- Principle is to have at least a **pair** of unique values in a test case
- Good values can use Equivalent Classes and Boundary Analisys
- Combinatorial can **optimally** test all values on a single test plan execution

Combinatorial Testing



Source: https://csrc.nist.gov/Projects/Automated-Combinatorial-Testing-for-Software

```
// qemu-img convert command line options
    [--object objectdef]  [--image-opts]
    [-c]
    [-p]
    [-q]
    [-n]
    [-f fmt]
    [-t cache]
    [-T src_cache]
    [-O output_fmt]
    [-o options]
    [-s snapshot_id_or_name]
    [-l snapshot_param]
    [-S sparse_size]
    [-m num_coroutines]
    [-W] filename [filename2 [...]] output_filename
```

```
// qemu-img convert command line options
    [--object objectdef]  [--image-opts]
    [-c]
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    [-l snapshot_param]
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    [-m num_coroutines]
    [-W] filename [filename2 [...]] output_filename
```

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