Software Testing: Why? How?

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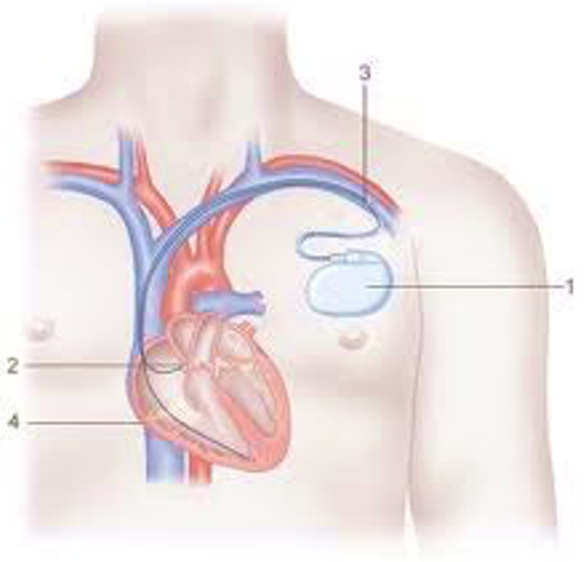
Why?
Software at Your Heart

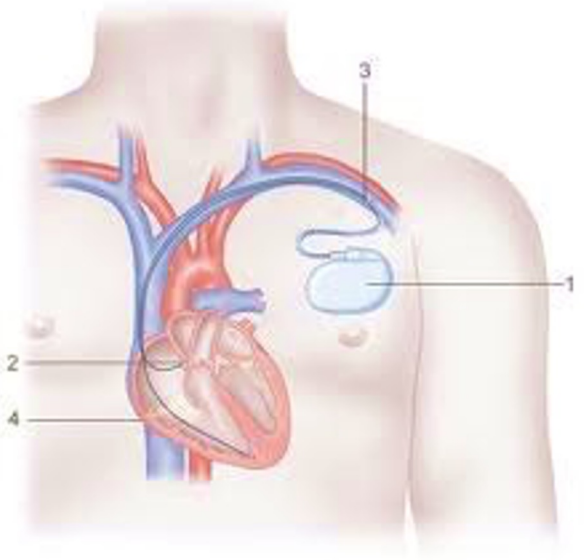
Software glitches in pacemakers

"Company said it has not received any reports of deaths or clinical complications resulting from the glitch, which appears in about 53 out of every 199,100 cases."



Why?
Software at Your Heart

At least 212 deaths from device failure in five different brands of implantable cardioverter-defibrillator (ICD) according to a study reported to the FDA



[Killed by Code, 2010]

Why?
Software at Critical Infrastructure

… a glitch caused more than 3,200 US prisoners to be released early. The software calculates a prisoner's sentence depending on good/bad behaviour and was introduced in 2002.

[BBC News 2015]

Photo by Thomas Hawk @ Flicker

Why?
Software at Your Car

Over the past two years Nissan has been recalling airbags adding up to over 1 million cars … due to a glitch in the airbag's sensory detectors. There has been a reported two accidents due to this software failure.

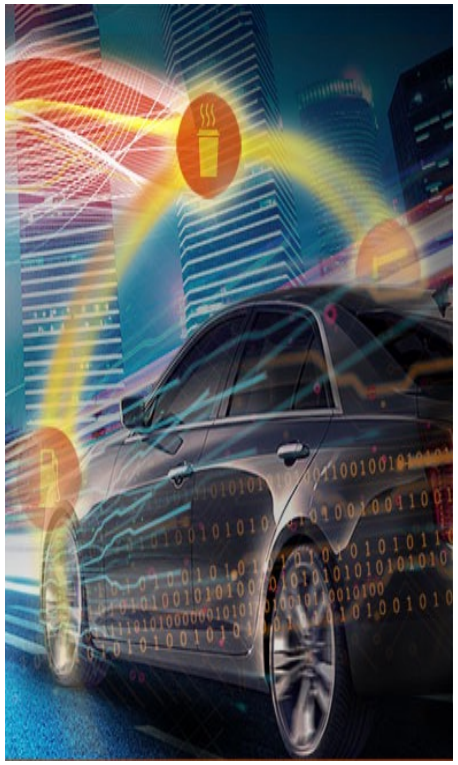
Photo from Wikipedia

Why?
Software Testing in Automotive

"if you bought a premium-class automobile recently, it probably contains close to **100 million lines of software code**.

All that software executes on **70 to 100** microprocessor-based electronic control units (**ECUs**) **networked** throughout the body of your car."

-- Manfred Broy,
IEEE Spectrum, 2009



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Why?
Software Testing in Automotive

"By 2025, the share of **software** in the car industry will increase to **25%** of the total value; the share of **software and hardware** will increase to **65%** of the total value."

--Roemer and Kramer
The Intelligent Car, 2010

Automotive CPS

Company	Autonomous miles	Disengagements	Rate per 1000 miles
Google	635868	124	0.20
Cruise	10015	284	28.36
Nissan	4099	28	6.83
Delphi	3125	178	56.95
Bosch	983	1442	1466.94
Mercedes	673	336	498.95
BMW	638	1	1.57
Ford	590	3	5.08
Tesla	550	182	330.91

Disengagement Rates for
Major Autonomous Vehicles

(source: IEEE Spectrum, February 2017)

Why?
Bugs (Faults): Facts of Life

"Coders introduce bugs at the rate of 4.2 defects per hour of programming. If you crack the whip and force people to move more quickly, things get even worse."

[Watts Humphreys]

Why?
Bugs (Faults): Facts of Life

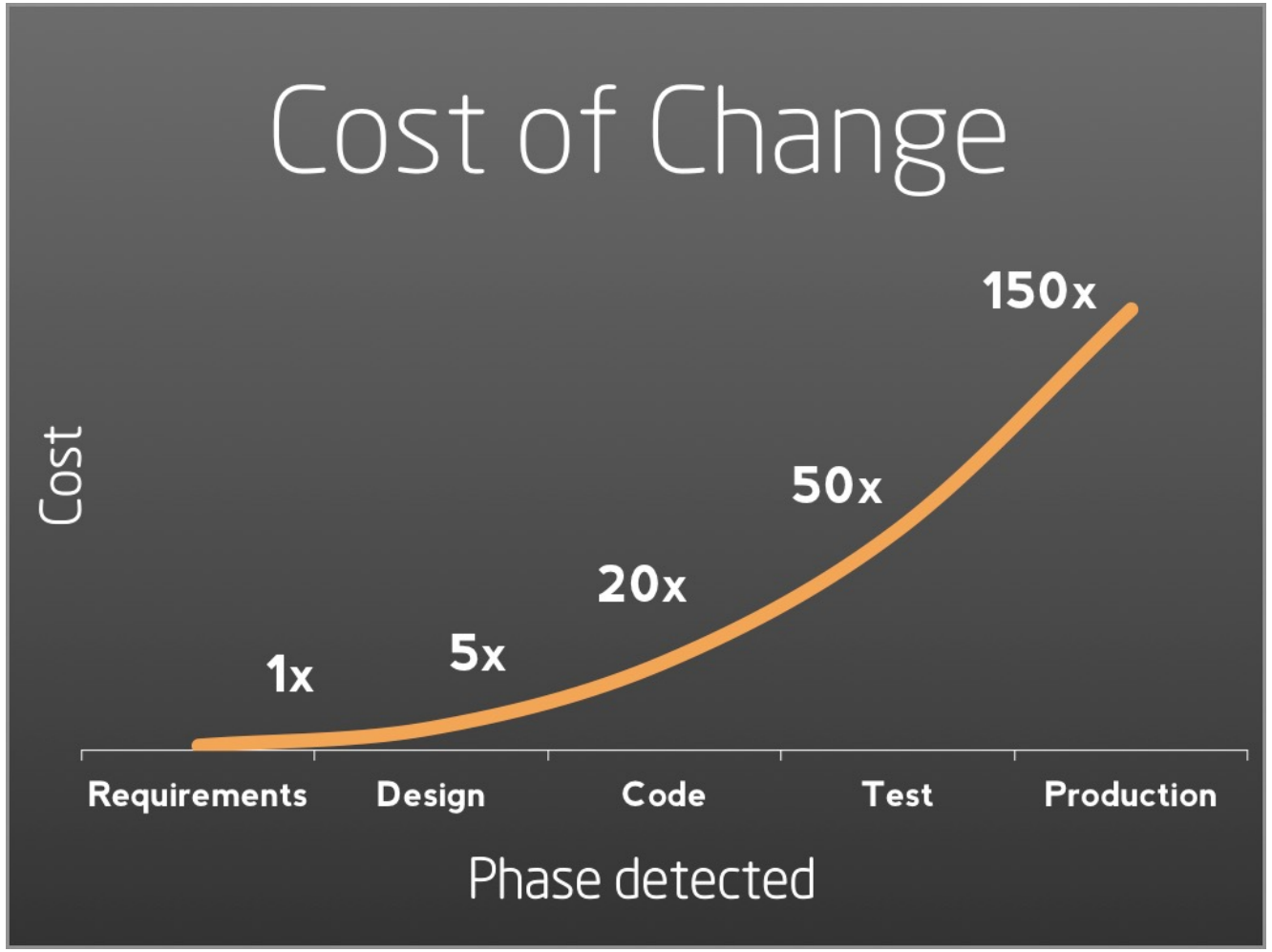
"Cost of software faults in 2016: 1100 Billion USD,

Number of people affected by software faults:
4.4 Billion people."

[Tricentis, Software Fail Watch, 2016]

Photo Copyright: Tricentis

Why?
Boehm's Curve



What?
Faults, Errors, Failures

- Fault: incorrect implementation:
  - commission: wrong implementation
  - omission: forgotten implementation (the more difficult one)
- Error: incorrect system state
- Failure (anomaly, incident) : visible error in the behavior

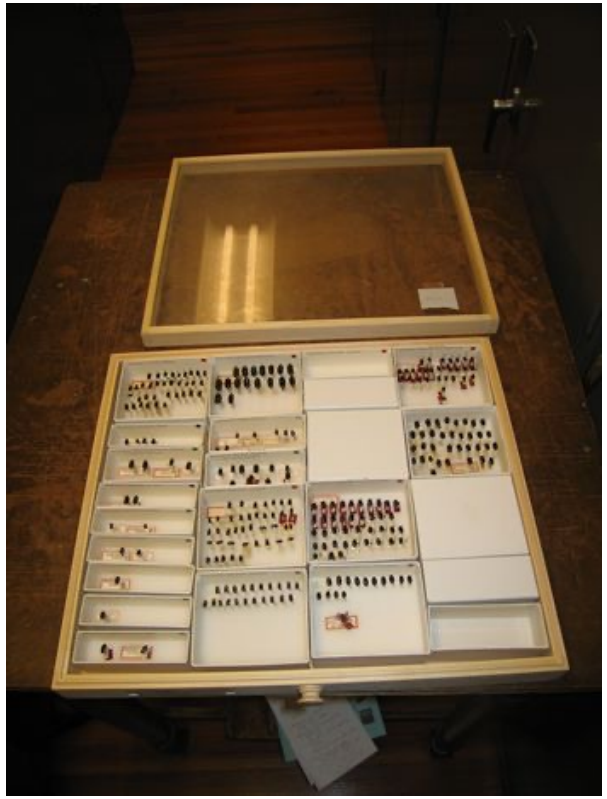


Photo from Wikipedia

Example

Spec: inputs an integer, and outputs $2*i^3$

Implementation:

```
#include <iostream>
#include  <math.h>

int main() {
    int i;
    cin >> i;
    i = 2 * i;
    i = pow(i, 3);
    cout << i;
   return 0;
}
```

Example

1. cin >> i;
2. i = 2 * i;
3. i = pow(i, 3);
4. cout << i;

- Conceptual mistake: confusing the binding power of operators
- Fault: Statements 2 and 3 are in the wrong order
- Error: State of the program after line 3 may have the wrong value for i.
- Failure:
  - Test-case: input 1, expected output 2.
  - Actual execution: input 1 ... output 8!

How?
Test-Case, Test-Suite

- **Test-Case:** a pair of
  - inputs (e.g., running environment, input values or pre-conditions, timing of events) and
  - expected outputs (e.g., concrete output values or symbolic properties input and output)

- **Test-Suite:** a set or list of test-cases

Thank you

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