COM4506/6506: Testing and Verification in Safety Critical Systems

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- Can I stop testing yet?
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- Code coverage that is better than line/statement coverage

Test Adequacy

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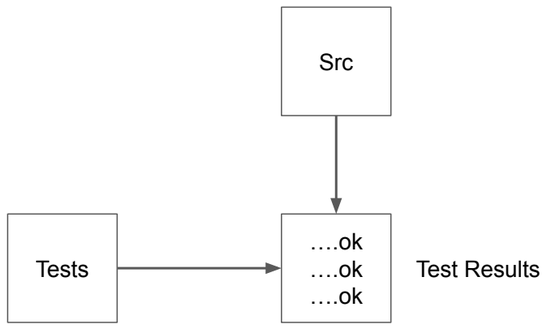
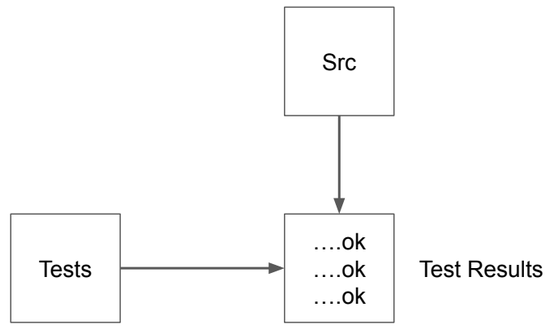
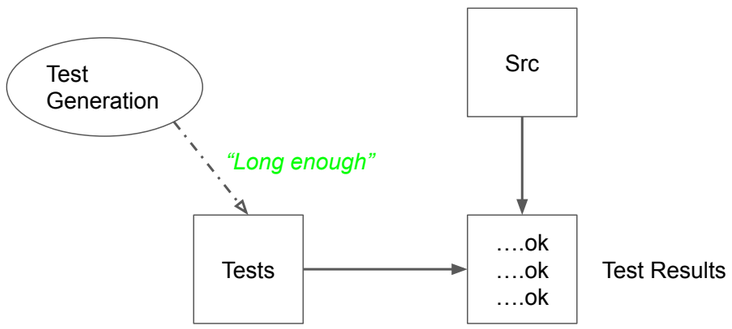


Test Adequacy

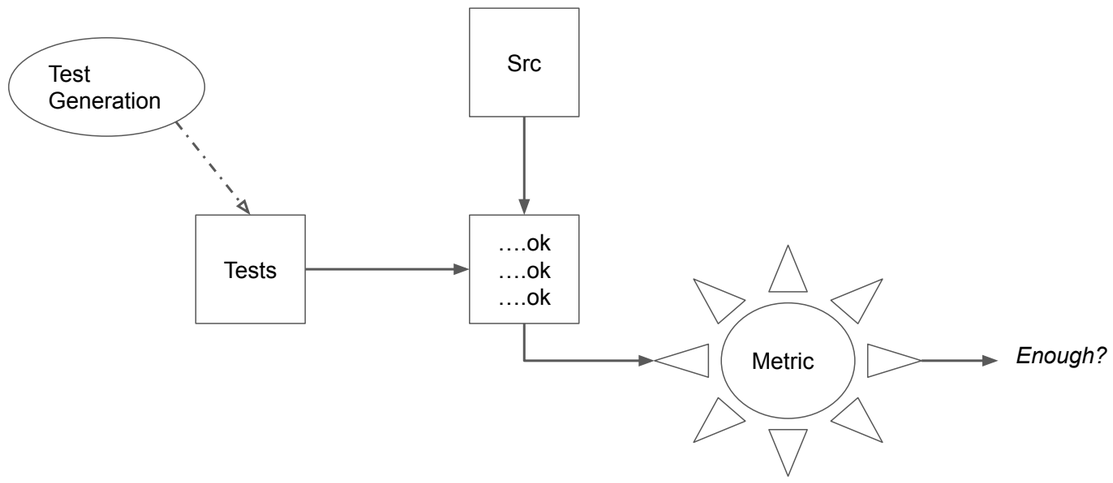


“Everything passes, its done, I’m going to the pub…”

Test Adequacy



Test Adequacy



Line/Statement Coverage

```
    |  -module(abiftest).
    |  -export([dv/2]).
    |
    |  dv(A,B) ->
0..|      if (A == 0) and (B > 4) ->
0..|           B;
    |         true ->
0..|           B / A
    |      end.
```

Line/Statement Coverage

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    |  -module(abiftest).
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    |
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1..|      if (A == 0) and (B > 4) ->
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    |      end.
```

dv(0,5)

Line/Statement Coverage

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dv(0,5)
dv(5,5)

Line/Statement Coverage

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    |  dv(A,B) ->
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1..|           B;
    |         true ->
1..|           B / A
    |      end.
```

dv(0,5)
dv(5,5)
dv(0,2)

** exception error: an error occurred when evaluating an arithmetic expression
in function abiftest:dv/2
(abiftest.erl, line 8)

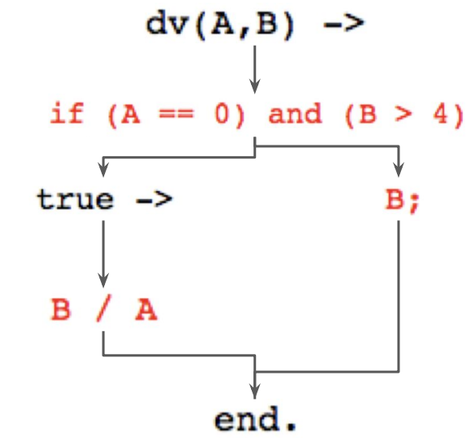
Line/Statement Coverage

- **Line coverage (or statement coverage) is a terrible metric for tests**
  - It only shows that you ran something *at all*, it tells you nothing about the circumstances

- **You should still achieve line coverage!** *Not even trying* bits of code would be bad
  - Line coverage is really easy to measure in most language environments

Branch Coverage

We can do better...



Branch Coverage

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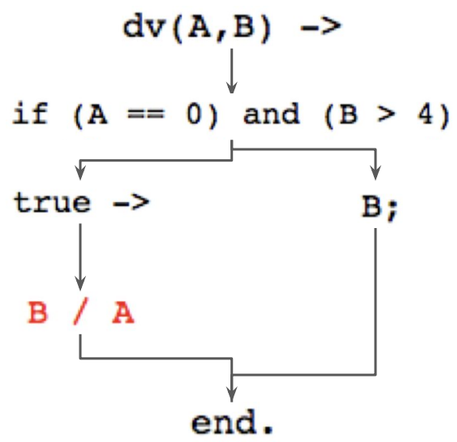
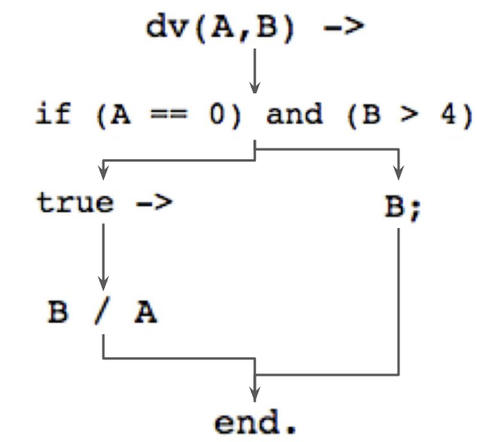


dv(0,5)

Branch Coverage

We can do better...

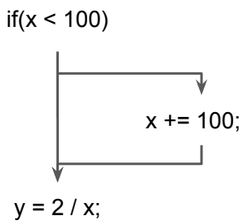


dv(0,5)
dv(5,5)

Branch Coverage

- Branch coverage doesn't help in that example (partly because its in Erlang!) but it can be useful in other cases.
- If statements without else statements are an obvious example.

```
if(x < 100) {
    x += 100;
}
y = 2 / x;
```



Condition Coverage

It still doesn't discuss *how* we got to this branch...

```
(A == 0) and (B > 4)
```

*This **decision** has two **conditions***

Condition Coverage

Condition coverage requires we try all evaluations for all *conditions*

```
(A == 0) and (B > 4)
```

dv(0,5)
dv(5,5)
dv(5,0)

A != 0	dv(5,5), dv(5,0)
A == 0	dv(0,5)
B =< 4	dv(5,0)
B > 4	dv(0,5), dv(5,5)

Condition Coverage

Condition coverage requires we try all evaluations for all *conditions*

```
(A == 0) and (B > 4)
```

dv(0,5)
dv(5,5)
dv(5,0)

We have both Branch and Condition Coverage, but we've still not hit the fault!

*Although we have made the Decision True and False, we haven't looked at all the **ways** to make it True and False using its conditions*

Modified Condition/Decision Coverage

Modified Condition/Decision Coverage

[...], every decision in the program has taken all possible outcomes at least once, and each condition in a decision has been shown to independently affect that decision's outcome. A condition is shown to independently affect a decision's outcome by varying just that condition while holding fixed all other possible conditions.

DO-178B [precursor to DO-178C]

Modified Condition/Decision Coverage

(A == 0) and (B > 4)

- matched: 1
- non-matched: 2

When false:

	matched	non-matched
A == 0	0	2
B > 4	1	1

dv(0,5)
dv(5,5)
dv(5,0)

Modified Condition/Decision Coverage

```
    |  -module(abiftest).
    |  -export([dv/2]).
    |
    |  dv(A,B) ->
2..|      if (A == 0) and (B > 4) ->
1..|           B;
    |         true ->
1..|           B / A
    |      end.
```

dv(0,5)
dv(5,5)
dv(5,0)
dv(0,2)

Summary

- We need some kind of metric for our test sets
  - To tell us whether they are any good
  - To tell us whether we can stop expanding them!
- Simply asking "does it actually run all the lines of code?" is a dreadful metric, but we should do at least that much!
- Looking at *how* we reached the code sections is important.
- MC/DC coverage is required by many Safety Critical Standards.