EEIE30069: VLSI Testing

Assignment 6

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I. Compile and execute

--How to compile:

In /podem directory, enter the following command:

$ make

It will generate the executable file "atpg" in this directory

--How to run:

In /podem directory, enter the following command:

For 1.-a :

$ ./run.sh ass6_a [backtrack num]

(will use b17.bench to run atpg)

e.g.:

$ ./run.sh ass6_a 100

For 1.-b:

$ ./run.sh ass6_b1 (atpg with checkpoint fault list and run fsim)

$ ./run.sh ass6_b2 (atpg with total fault list and run fsim)

e.g.:

$ ./run.sh ass6_b

For 1.-c

$ ./run.sh ass6_c (print c17 procedure)

e.g.:

$ ./run.sh ass6_c

For 1.-d

$ ./run.sh ass6_d [circuit name]

e.g.:

$ ./run.sh ass6_d

For 1.-e

$ ./run.sh ass6_e [circuit name]

e.g.:

$ ./run.sh ass6_e b17

II. Overview of my method

For 1.-d

In the first stage, we will generate 1000 patterns, and this pattern will used to do fault simulations one by one. If the coverage reaches 90%, then break the while loop and run the original atpg in the second stage. If not, it will test all 1000 pattern, and run the original atpg in the second stage as well.

For 1.-e

The program is written in bfatpg.cc. The program will use bridging fault list to run PODEM. The program will compare two net values the pattern gives and decide whether the pattern can detect the bridging fault. The table below shows the detected bridging fault pattern.

original a b	Wired-OR a^+ b^+	Wired-AND a^+ b^+
0 0	0 0	0 0
0 1	1 1	0 0
1 0	1 1	0 0
1 1	1 1	1 1

III. Result and analysis

For 1. -a (b17) backtrack limits=1

number of patterns: 41647

fault coverages: 55%

CPU run times: 785.01

actual backtrack numbers: 68413

```
backtrack limit = 1
---------------------------------------
Test pattern number = 41647
Total backtrack number = 68413
---------------------------------------
Total fault number = 142884
Detected fault number = 78584
Undetected fault number = 64300
Abort fault number = 63861
Redundant fault number = 439
---------------------------------------
Total equivalent fault number = 142884
Equivalent detected fault number = 78584
Equivalent undetected fault number = 64300
Equivalent abort fault number = 63861
Equivalent redundant fault number = 439
---------------------------------------
Fault Coverge = 55.00%
Equivalent FC = 55.00%
Fault Efficiency = 55.17%
---------------------------------------
total CPU time = 785.01
```

For 1. -a (b17) backtrack limits=10

number of patterns: 72511

fault coverages: 82.09%

CPU run times: 1285.96

actual backtrack numbers: 376982

```
backtrack limit = 10
---------------------------------------
Test pattern number = 72511
Total backtrack number = 376982
---------------------------------------
Total fault number = 142884
Detected fault number = 117297
Undetected fault number = 25587
Abort fault number = 25080
Redundant fault number = 507
---------------------------------------
Total equivalent fault number = 142884
Equivalent detected fault number = 117297
Equivalent undetected fault number = 25587
Equivalent abort fault number = 25080
Equivalent redundant fault number = 507
---------------------------------------
Fault Coverge = 82.09%
Equivalent FC = 82.09%
Fault Efficiency = 82.38%
---------------------------------------
total CPU time = 1285.96
```

For 1. -a (b17) backtrack limits=100

number of patterns: 84711

fault coverages: 90.01%

CPU run times: 1496.43

actual backtrack numbers: 1821691

```
backtrack limit = 100
---------------------------------------
Test pattern number = 83711
Total backtrack number = 1821691
---------------------------------------
Total fault number = 142884
Detected fault number = 128608
Undetected fault number = 14276
Abort fault number = 13584
Redundant fault number = 692
---------------------------------------
Total equivalent fault number = 142884
Equivalent detected fault number = 128608
Equivalent undetected fault number = 14276
Equivalent abort fault number = 13584
Equivalent redundant fault number = 692
---------------------------------------
Fault Coverge = 90.01%
Equivalent FC = 90.01%
Fault Efficiency = 90.45%
---------------------------------------
total CPU time = 1496.43
```

For 1. -a (b17) backtrack limits=1000

number of patterns: 86025

fault coverages: 91.62%

CPU run times: 3942.69

actual backtrack numbers: 12664818

```
backtrack limit = 1000
---------------------------------------
Test pattern number = 86025
Total backtrack number = 12664818
---------------------------------------
Total fault number = 142884
Detected fault number = 130917
Undetected fault number = 11967
Abort fault number = 10933
Redundant fault number = 1034
---------------------------------------
Total equivalent fault number = 142884
Equivalent detected fault number = 130917
Equivalent undetected fault number = 11967
Equivalent abort fault number = 10933
Equivalent redundant fault number = 1034
---------------------------------------
Fault Coverge = 91.62%
Equivalent FC = 91.62%
Fault Efficiency = 92.29%
---------------------------------------
total CPU time = 3942.69
```

For 1.-b

test vector with checkpoint fault list(left), fsim on the total fault list(right)

```
Generate checkpoint fault list
Run stuck-at fault ATPG
compute fault coverage
backtrack limit = 1
----------------------------------------
Test pattern number = 25694
Total backtrack number = 40088
----------------------------------------
Total fault number = 81330
Detected fault number = 43157
Undetected fault number = 38173
Abort fault number = 37802
Redundant fault number = 371
----------------------------------------
Total equivalent fault number = 81330
Equivalent detected fault number = 43157
Equivalent undetected fault number = 38173
Equivalent abort fault number = 37802
Equivalent redundant fault number = 371
----------------------------------------
Fault Coverge = 53.06%
Equivalent FC = 53.06%
Fault Efficiency = 53.31%
----------------------------------------
total CPU time = 295.63
```

```
Run stuck-at fault simulation
PatternNum: 16
----------------------------------------
Test pattern number = 25694
----------------------------------------
Total fault number = 142884
Detected fault number = 120426
Undetected fault number = 22458
----------------------------------------
Equivalent fault number = 142884
Equivalent detected fault number = 120426
Equivalent undetected fault number = 22458
----------------------------------------
Fault Coverge = 84.28%
Equivalent FC = 84.28%
----------------------------------------
total CPU time = 146.67
```

test vector with total fault list(left), fsim on the total fault list (right)

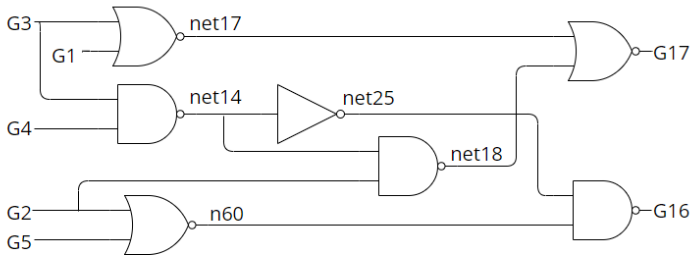
```
Generate stuck-at fault list
Run stuck-at fault ATPG
----------------------------------------
Test pattern number = 41647
Total backtrack number = 68413
Backtrack limit = 1
----------------------------------------
Total fault number = 142884
Detected fault number = 78584
Undetected fault number = 64300
Abort fault number = 63861
Redundant fault number = 439
----------------------------------------
Total equivalent fault number = 142884
Equivalent detected fault number = 78584
Equivalent undetected fault number = 64300
Equivalent abort fault number = 63861
Equivalent redundant fault number = 439
----------------------------------------
Fault Coverge = 55.00%
Equivalent FC = 55.00%
Fault Efficiency = 55.17%
----------------------------------------
total CPU time = 791.37
```

```
Run stuck-at fault simulation
----------------------------------------
Test pattern number = 41647
Parallel PatternNum: 16
----------------------------------------
Total fault number = 142884
Detected fault number = 122354
Undetected fault number = 20530
----------------------------------------
Equivalent fault number = 142884
Equivalent detected fault number = 122354
Equivalent undetected fault number = 20530
----------------------------------------
Fault Coverge = 85.63%
Equivalent FC = 85.63%
----------------------------------------
total CPU time = 182.44
```

From the result, we can see that the test vector with a checkpoint fault list generates fewer pattern number than the test vector with a total fault. The fault coverage is different, the test vector with the total fault list has a higher coverage. However, it needs much more CPU runtime and pattern number.

For 1.-c

```
Generate c17 fault list
Run stuck-at fault ATPG
---------------------- Run PODEM -----------------------
Fault: net17 0
  decision point: G1  0
  fault propagate gate: G16
  decision point: G2  0
---------------------- Run PODEM -----------------------
Fault: n60 1
  decision point: G2  1
  fault propagate gate: G17
  decision point: G3  0
```



In net17 s.a.0 case, fault activation set net17=1, we can find the decision G1=0, then fault propagate to G16, and new decision point is G2=0

In n60 s.a.1 case, fault activation set n60=0, we can find the decision G2=1, then fault propagate to G17, and new decision point is G3=0

Both net17 s.a.0 and n60 s.a.1 no need to backtrack the decision to find the test pattern.

For 1.-d

For b17,bench

```
Can't reach 100% coverage with random pattern (53.211/90)
Run stuck-at fault ATPG
---------------------------------------
Test pattern number = 24022
Total backtrack number = 270757
Backtrack limit = 10
---------------------------------------
Total fault number = 142884
Detected fault number = 123886
Undetected fault number = 18998
Abort fault number = 18637
Redundant fault number = 361
---------------------------------------
Total equivalent fault number = 142884
Equivalent detected fault number = 123886
Equivalent undetected fault number = 18998
Equivalent abort fault number = 18637
Equivalent redundant fault number = 361
---------------------------------------
Fault Coverge = 86.70%
Equivalent FC = 86.70%
Fault Efficiency = 86.92%
---------------------------------------
total CPU time = 207.09
```

For s35932_com

```
Can't reach 100% coverage with random pattern (89.6889/90)
Run stuck-at fault ATPG
---------------------------------------
Test pattern number = 1000
Total backtrack number = 51200
Backtrack limit = 10
---------------------------------------
Total fault number = 71224
Detected fault number = 63880
Undetected fault number = 7344
Abort fault number = 5120
Redundant fault number = 2224
---------------------------------------
Total equivalent fault number = 71224
Equivalent detected fault number = 63880
Equivalent undetected fault number = 7344
Equivalent abort fault number = 5120
Equivalent redundant fault number = 2224
---------------------------------------
Fault Coverge = 89.69%
Equivalent FC = 89.69%
Fault Efficiency = 92.58%
---------------------------------------
total CPU time = 13.54
```

For s38417_com

```
Can't reach 100% coverage with random pattern (88.7882/90)
Run stuck-at fault ATPG
---------------------------------------
Test pattern number = 2118
Total backtrack number = 2175
Backtrack limit = 10
---------------------------------------
Total fault number = 76678
Detected fault number = 76413
Undetected fault number = 265
Abort fault number = 148
Redundant fault number = 117
---------------------------------------
Total equivalent fault number = 76678
Equivalent detected fault number = 76413
Equivalent undetected fault number = 265
Equivalent abort fault number = 148
Equivalent redundant fault number = 117
---------------------------------------
Fault Coverge = 99.65%
Equivalent FC = 99.65%
Fault Efficiency = 99.81%
---------------------------------------
total CPU time = 7.33
```

For s38584_com

```
Can't reach 100% coverage with random pattern (87.8578/90)
Run stuck-at fault ATPG
---------------------------------------
Test pattern number = 1600
Total backtrack number = 9907
Backtrack limit = 10
---------------------------------------
Total fault number = 76864
Detected fault number = 73457
Undetected fault number = 3407
Abort fault number = 655
Redundant fault number = 2752
---------------------------------------
Total equivalent fault number = 76864
Equivalent detected fault number = 73457
Equivalent undetected fault number = 3407
Equivalent abort fault number = 655
Equivalent redundant fault number = 2752
---------------------------------------
Fault Coverge = 95.57%
Equivalent FC = 95.57%
Fault Efficiency = 99.12%
---------------------------------------
total CPU time = 8.72
```

Using a random pattern in the first stage, we can find out that it can significantly reduce the CPU run time to run ATPG in the second stage.

For 1.-e bridging fault atpg(left), bridging fault simulation(right)

```
run bridging fault ATPG
Generate bridging fault list
Bridging fault number:16
Run bridging fault ATPG
---------------------------------------
Test pattern number = 7
Total backtrack number = 13
Backtrack limit = 10000
---------------------------------------
Total fault number = 16
Detected fault number = 13
Undetected fault number = 3
Abort fault number = 0
Redundant fault number = 3
---------------------------------------
Total equivalent fault number = 0
Equivalent detected fault number = 13
Equivalent undetected fault number = 3
Equivalent abort fault number = 0
Equivalent redundant fault number = 3
---------------------------------------
Fault Coverge = 81.25%
Equivalent FC = 81.25%
Fault Efficiency = 100.00%
---------------------------------------
total CPU time = 0.00
```

```
Start parsing input file
Finish reading circuit file
run bridging fault simulation
Generate bridging fault list
Bridging fault number:16
Run bridging fault simulation
PatternNum: 16
---------------------------------------
Test pattern number = 2
---------------------------------------
Total fault number = 16
Detected fault number = 7
Undetected fault number = 9
---------------------------------------
Equivalent fault number = 16
Equivalent detected fault number = 7
Equivalent undetected fault number = 9
---------------------------------------
Fault Coverge = 43.75%
Equivalent FC = 43.75%
---------------------------------------
total CPU time = 0.00
```