On Comparison of Random, Partition, and Proportional Partition Testing

In IEEE Transactions on Software Engineering, October 2001
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Road Map
- Introduction
- Previous Studies
- The Experiment
- Results: Proportional Partition vs Random
- Results: Partition vs. Random with other factors
- Conclusion

Introduction
- Random Testing
  - Random selection of test cases from ENTIRE input domain
  - Successfully employed in practice
  - Relatively easy to employ
    - Effort
    - Cost
  - Problems
    - No guarantee
    - Not systematic

Introduction (cont)
- Partition Testing
  - Partition into disjoint sub-domains
  - Coverage of all sub-domains
  - At least one test case from each sub-domain
  - Problems
    - Can not truly have disjoint sub-domains
    - Is one test case per sub-domain enough?

Introduction (cont)
- Proportional Partition Testing
  - Associates a probability \( p \) to each sub-domain
  - Probability \( p \) based on when that sub-domain is likely to occur.
  - \( n \) testcases to the \( k \) sub-domains according to \( p \)
  - Example
    - Grades
  - Problems
    - 2 sub-domains and a million test cases

Previous Studies
- Duran and Ntafos
  - July 1984
  - Performance of random and partition very close
  - Random more cost-effective than partition
- Hamlet Taylor
  - Dec 1990
  - Similar results
Previous Studies (cont)

- Weyuker and Jeng
  - July 1991
  - Partition testing ‘at least’ as well as random
  - ‘IF’ sub-domains are of equal size
- Most Studies:
  - ‘Proportional partition testing’ as the strategy increases the chances of proper coverage of the particular sub-domain

Problems:

- Non-realistic approach- looked at:
  - How many times random testing did better than proportional partition testing
  - $P_r > P_p$
  - What about ‘did as well as’?
- Other factors
  - Cost
  - Effectiveness

The Experiment

- “Simulations”
  - Details in Duran and Ntafos, July 1984
  - $k = 20$ sub-domains
  - $20 \leq n \leq 800$ test cases
  - Probability and failure rate for $(k,n)$ generated
  - Each experiment run 1000 times
  - $P_r$ = Probability of random test detecting at least one failure
  - $P_p$ = Probability of partition test detecting at least one failure

The Experiment (cont)

- Proportional partition vs. random testing
  - Three sets of experiments
  - Small number of sub-domains
  - Vary the number of sub-domains
  - Vary the number of test cases
  - Vary the failure rates
- Partition vs. random testing with cost and effectiveness as factors
  - Five sets of experiments
  - Vary the failure rate distribution
  - Vary the number of test cases

Results: Proportional vs. Random

- ‘U curve’: realistic

Results: Proportional vs. Random (cont)

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Random vs. Proportional Partition Testing ($n = 100$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>Random vs. group</td>
</tr>
<tr>
<td>20</td>
<td>0.453 ± 0.515</td>
</tr>
<tr>
<td>40</td>
<td>0.675 ± 0.725</td>
</tr>
<tr>
<td>60</td>
<td>0.898 ± 0.932</td>
</tr>
<tr>
<td>80</td>
<td>1.121 ± 1.162</td>
</tr>
<tr>
<td>100</td>
<td>1.346 ± 1.381</td>
</tr>
<tr>
<td>120</td>
<td>1.571 ± 1.603</td>
</tr>
<tr>
<td>140</td>
<td>1.796 ± 1.828</td>
</tr>
<tr>
<td>160</td>
<td>2.021 ± 2.052</td>
</tr>
<tr>
<td>180</td>
<td>2.246 ± 2.276</td>
</tr>
</tbody>
</table>

The U curve: realistic
Results: Proportional vs. Random (cont) [vary k and failure rates]

- Similar with a minor delay

Results: Proportional vs. Random (cont) [vary k and failure rates]

- As failure rate becomes smaller, longer delay
  - BUT same shape

Results: Proportional vs. Random

- Proportional Partition Testing is not more effective than Random
- Random Testing does ‘as well as’ Proportional Testing
- Proportional Testing not a worthwhile goal due to other factors

Results: Partition vs. Random

- Other factors
  - Cost
    - Hard to measure
    - Data not easy to obtain
    - E.g.
      - Cost of preparing and executing test cases
      - Training for the technique
      - Cost of failures left undetected
      - Testing Tools

Results: Partition vs. Random (cont)

- Other factors (cont)
  - Relative effectiveness
    - Selecting test cases in partition testing
    - Functional testing
    - Fault-based strategies
  - Homogeneity of faults

Results: Partition vs. Random (cont)

- For simulations
  - Translate cost and relative effectiveness into equivalent number of additional test cases
  - It takes $x$ number of random test cases to be equivalent to the $n$ number of partition testing
  - $x = m^n$
Results: Partition vs. Random (cont)

- Set 1
  - $k=20$, $n=20$, failure rate dist.: (0,0.1]
- Set 2
  - $k=20$, $n=20$, failure rate dist.: (0,0.001]
- Set 3
  - $k=20$, $n=20$, failure rate dist.: 95% in (0,0.1]
- Set 4
  - $k=20$, $n=40$, failure rate dist.: 95% in (0,0.1]
- Set 5
  - $k=20$, $n=20$, failure rate dist.: 95% in (0,0.1]

Moral of the Story:
- If Homogeneity, use Partition Testing
- Else, use Random Testing
- Homogeneity is not always true in practice

Results: Partition vs. Random (cont)

<table>
<thead>
<tr>
<th>Set</th>
<th>Proportional Test</th>
<th>Random Test</th>
<th>Proportional Test</th>
<th>Random Test</th>
<th>Proportional Test</th>
<th>Random Test</th>
<th>Proportional Test</th>
<th>Random Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.98</td>
<td>0.97</td>
<td>0.98</td>
<td>0.97</td>
<td>0.98</td>
<td>0.97</td>
<td>0.98</td>
<td>0.97</td>
</tr>
<tr>
<td>2</td>
<td>0.99</td>
<td>0.99</td>
<td>0.99</td>
<td>0.99</td>
<td>0.99</td>
<td>0.99</td>
<td>0.99</td>
<td>0.99</td>
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<tr>
<td>3</td>
<td>0.96</td>
<td>0.96</td>
<td>0.96</td>
<td>0.96</td>
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<td>0.96</td>
<td>0.96</td>
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<tr>
<td>4</td>
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<td>0.95</td>
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<tr>
<td>5</td>
<td>0.94</td>
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</tbody>
</table>

Conclusion

- Proportional Testing is not the ‘way’ to do testing
- Random Testing has advantage when no homogeneity and cost-effectiveness factors included
  - IF random is less effective and cheaper than partition
- "Simulations":
  - More empirical studies necessary?