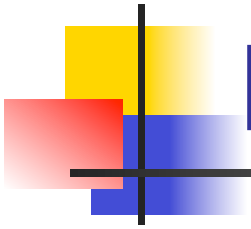
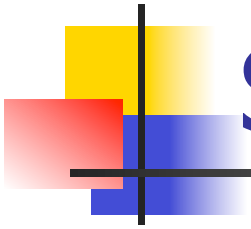
Structural Testing Review

Chapter 10



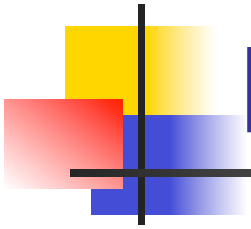
Measuring Gaps and Redundancy

- We have seen that functional testing methods may produce test suites with serious gaps and a lot of redundancy
- Structural testing analysis allows to measure the extent of these problems



Structural Metrics

- A functional testing method M produces m test cases
- A structural metric S identifies s coverage elements in the unit under test
- When the m test cases run, they traverse n coverage elements



Metric definitions

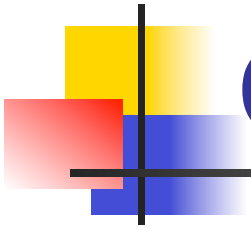
- **Coverage** of method M with respect to metric S as C(M,S) = n/s
- **Redundancy** of method M with respect to metric S as R(M,S) = m/s
- **Net redundancy** of method M with respect to metric S as NR(M,S) = m/n

Metric values for Triangle

Method	m	n	s	C(M,S)	R(M,S)	NR(M,S)
Boundary Value	15	7	11	0.64	1.36	2.14
Worst Case Analysis	125	11	11	1.00	11.36	11.36
WN ECT	4	4	11	0.36	0.36	1.00
Decision Table	8	8	11	0.72	0.72	1.00

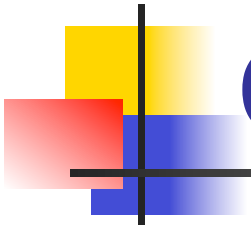
Metric values for Commission

Method	m	n	s	C(M,S)	R(M,S)
Output BVA	25	11	11	1	2.27
Decision table	3	11	11	1	0.27
DD-path	25	11	11	1	2.27
DU-path	25	33	33	1	0.76
Slice	25	40	40	1	0.63



Coverage usefulness

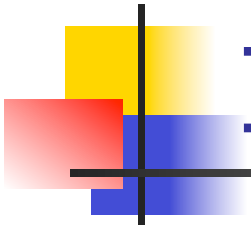
- 100% coverage is never a guarantee of bug-free software
- Coverage reports can
  - point out inadequate test suites
  - suggest the presence of surprises, such as blind spots in the test design
  - Help identify parts of the implementation that require structural testing



Coverage example

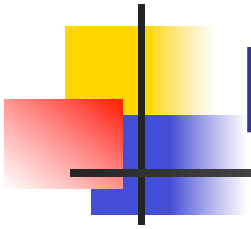
- TEX and AWK are widely used programs with comprehensive test suites
- Coverage analysis showed

System	Segment	Branch	P-use	C-use
TEX	85	72	53	48
AWK	70	59	48	55



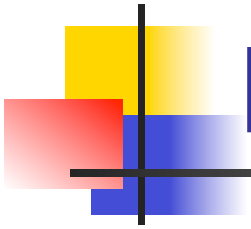
Is 100% coverage possible?

- Short-circuit evaluation
- Mutually exclusive conditions
  - `(x > 2) || (x < 10)`
- Redundant predicates
  - `if (x == 0) do1; else do2;`
    `if (x != 0) do3; else do4;`
- Dead code
- “This should never happen”



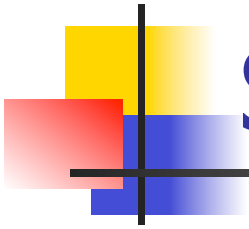
How to measure coverage?

- The source code is instrumented
- Depending on the code coverage model, code that writes to a trace file is inserted in every branch, statement etc.
- Most commercial tools measure segment and branch coverage



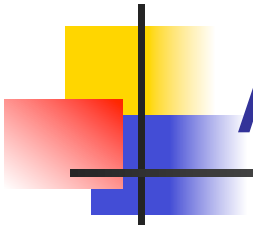
FAQ about Coverage

- Is 100% coverage the same as exhaustive testing?
- Are branch and path coverage the same?
- Can path coverage be achieved?
- Is every path in a control flow graph testable?
- Is less than 100% coverage acceptable?
- Can I trust a test suite without measuring coverage?
- When can I stop testing?



Some answers…

- When you run out of time
- When continued testing reveals no new faults
- When you cannot think of any new test cases
- When you reach a point of diminishing returns
- When mandated coverage has been attained
- When all faults have been removed



A coverage counter-example

```
void Depository::give_change(int price)
{
  int n_100, n_25, n_10, n_5;
  if (deposit <= price) {
    change_due = 0;
  }
  else {
    change_due = deposit-price;
    n_100      = change_due / 100;
    change_due = change_due - n_100*100;
    n_25       = change_due / 25;
    change_due = change_due - n_25*25;
    n_10       = change_due / 10;
    change_due = change_due - n_10*10;
    n_5        = change_due / 10; // A cut-and paste bug
  }
}
```