Today’s Lecture

• White-Box Testing
  – Control Flow Graphs
    • Coverage Criteria

Testing Approaches

• Black Box Testing
  – Tests are selected based on specification of intended functionality
  – Tester can only see interface to test subject
  – Emphasis on proper use of test subject

• White Box Testing
  – Tests are selected based on internal structure
  – Tester can see inside test subject
  – Emphasis on proper structure of test subject

White-box Testing: Coverage

• Statement Coverage
• Edge Coverage (Branch Coverage)
• Condition Coverage (Edge Coverage)
• Path Coverage

Details to follow...
Flow Graphs

Graph representation of control flow and data flow relationships

• Control Flow
  The partial order of statement execution, as defined by the semantics of the language

• Data Flow
  The flow of values from definitions of a variable to its uses

A Sample Ada Program to Test

```ada
function P return INTEGER is
begin
  X, Y: INTEGER;
  READ(X); READ(Y);
  while (X > 10) loop
    X := X – 10;
    exit when X = 10;
  end loop;
  if (Y < 20 and then X mod 2 = 0) then
    Y := Y + 20;
  else
    Y := Y – 20;
  end if;
  return 2 * X + Y;
end P;
```

P’s Control Flow Graph (CFG)

White-box Testing Criteria

• Statement Coverage
  Select a test set $T$ such that, by executing $P$ for each $d$ in $T$, each elementary statement of $P$ is executed at least once
All-Statements Coverage of P

Example all-statements-adequate test set:

(X = 20, Y = 10)

(X = 20, Y = 30)

White-box Testing Criteria

• Edge Coverage

Select a test set $T$ such that, by executing $P$ for each $d$ in $T$, each edge of $P$’s control flow graph is traversed at least once.
All-Edges Coverage of P

Example all-edges-adequate test set:

(X = 20, Y = 10)

(X = 15, Y = 30)

White-box Testing Criteria

• Condition Coverage
  Select a test set \( T \) such that, by executing \( P \) for each \( d \) in \( T \), each edge of \( P \)'s control flow graph is traversed at least once and all possible values of the constituents of compound conditions are exercised at least once.
Example all-conditions-adequate test set:

\[(X = 20, Y = 10)\]

\[(X = 5, Y = 30)\]

\[(X = 21, Y = 10)\]
White-box Testing Criteria

• Path Coverage
  Select a test set $T$ such that, by executing $P$ for each $d$ in $T$, all paths leading from the initial to the final node of $P$’s control flow graph are traversed at least once.

Example all-paths-adequate test set:

$(X = 5, Y = 10)$
Example all-paths-adequate test set: 
\((X = 5, Y = 10)\)
Example all-paths-adequate test set:
(X = 5, Y = 10)
(X = 15, Y = 10)
Example all-paths-adequate test set:

(X = 5, Y = 10)
(X = 15, Y = 10)
Example all-paths-adequate test set:
(X = 5, Y = 10)
(X = 15, Y = 10)
Example all-paths-adequate test set:
(X = 5, Y = 10)
(X = 15, Y = 10)
(X = 25, Y = 10)
Example all-paths-adequate test set:
(X = 5, Y = 10)
(X = 15, Y = 10)
(X = 25, Y = 10)
Example all-paths-adequate test set:
(X = 5, Y = 10)
(X = 15, Y = 10)
(X = 25, Y = 10)
All-Paths Coverage of P

Example all-paths-adequate test set:
(X = 5, Y = 10)
(X = 15, Y = 10)
(X = 25, Y = 10)

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