Revision: data flow based coverage — solutions

(code taken from 2008 exam, question 2)

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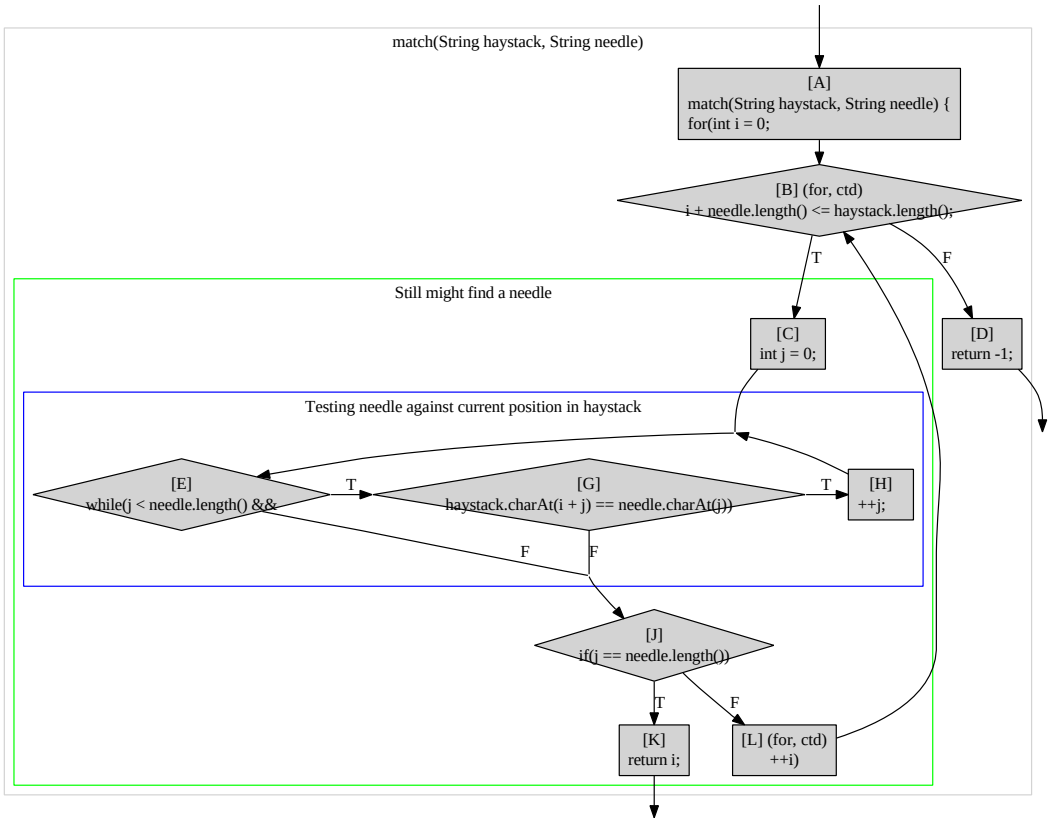
March 17, 2009

It's very important to know your coverage criteria definitions when attempting this kind of question. It's also worth doing one or two run-throughs with some simple inputs just to familiarise yourself with the code before you start to design your tests.

1. Control flow graph:



Note how the `for` loop is broken up over three nodes: **A**, **B** and **L**.

(In this case there are no nodes labelled **F** or **I** in order to avoid confusion with **F**alse branches, digit 1, letter l, etc.)

2. Annotations — note that the simplest thing is to write these on the graph itself, but *typesetting* that would be a lot of work.

Node	Defs/uses		
A	defs={haystack,needle,i}	G	p-uses={haystack,i,j,needle}
B	p-uses={i,needle,haystack}	H	defs={j}; c-uses={j}
C	defs={j}	J	p-uses={j,needle}
D	[none]	K	c-uses={i}
E	p-uses={j,needle}	L	defs={i}; c-uses={i}

3. Table: this is the same information as above, but now keyed by variable. This presentation makes it easier to identify all of the def-use pairs.

Variable	defs	c-uses	p-uses
haystack	A		BC,BD,GH,GJ
needle	A		BC,BD,EG,EJ,GH,GJ,JK,JL
i	A,L	K,L	BC,BD,GH,GJ
j	C,H	H	EG,EJ,GH,GJ,JK,JL

4. Def-use pairs. Note here that variables i and j have more than one definition, so the issue of *def-clear paths* comes up. Consequently when designing paths to cover a du-pair (X,Y), we must be careful that the path between **X** and **Y** is def-clear for any relevant variables.

   all-defs: (A,B/G); (A,B/E/G/J); (A,K/L/B/G); (L,K/L/B/G); (C,H/E/G/J); (H,H/E/G/J)

   (X,Y/Z) means at least one of (X,Y) or (X,Z); note that I don't specify which branch ((A,BC) vs (A,BD)) because it doesn't matter if all we want is *at least one* — once we've reached **B** from **A**, any branch will satisfy all-defs, be it **BC** or **BD**.

   all-c-uses: (A,K); (A,L); (L,K); (L,L); (C,H); (H,H)

   all-p-uses: (A,BC); (A,BD); (A,GH); (A,GJ); (A,EG); (A,EJ); (A,JK); (A,JL); (L,BC); (L,BD); (L,GH); (L,GJ); (C,EG); (C,EJ); (C,GH); (C,GJ); (C,JK); (C,JL); (H,EG); (H,EJ); (H,GH); (H,GJ); (H,JK); (H,JL)

   all-uses: union of all-c-uses and all-p-uses.

5. Any the same? No, but notice that if you satisfy all-p-uses it's clear from the def-use table that you'll automatically satisfy all-defs. This isn't always true. Be aware of the graphs showing subsumption relationships in the slides.

6. Does an all-defs-adequate suite need to satisfy statement coverage? No: you could satisfy all-defs without ever reaching node **D** for example.

7. Test suites:

   all-defs: `match("xy", "xz")` $\rightarrow -1$ would cause the path **ABCEGHEGJLBD** to be executed. This satisfies all-defs.

all-c-uses: Two tests are needed:

- `match("x", "x")` → 0 would cause the path **ABCEGHEJK** to be executed. This covers pairs (A,K) and (C,H) from our path set, leaving (A,L), (L,K), (L,L) and (H,H) still to cover.
- To get (L,L) and (H,H) we need to see more than one iteration of both the i-loop and the j-loop. Adding `match("yyxx", "xx")` → 2 to the suite will execute the path **ABCEGJLBCEJLBCEGHEGHEJK**, which covers all of these remaining pairs.

Note that the first test is necessary since the second test doesn't contain a def-clear path for i from **A** to **K** since the second test's path contains node **L** (redefining i) between **A** and **K**.

all-p-uses: A much longer list of def-use pairs to cover...

- `match("", "x")` → −1 will execute path **ABD**, covering (A,BD).
- `match("x", "")` → 0 will execute path **ABCEJK**, covering (A,BC), (A,EJ), (A,JK), (C,EJ), and (C,JK).
- `match("y", "x")` → −1 will execute path **ABCEGJLBD**, covering (A,GJ), (A,EG), (A,JL), (L,BD), (C,EG), (C,GJ) and (C,JL).
- `match("yyyx", "yx")` → 2 will execute path **ABCEGHEGJLBCEGHEGJLBCEGHEGHEJK**, covering (A,GH), (L,BC), (L,GH), (L,GJ), (C,GH), (H,EG), (H,EJ), (H,GH), (H,GJ), (H,JK) and (H,JL).

The technique here is to see what you haven't covered, then add a test targetting some of the uncovered d-u pairs (or even a random test if you're stuck), then see what you still haven't covered, and so on.

all-uses: The above all-p-uses test actually covers all-c-uses too, so it's also all-uses-adequate.

8. To achieve all-du-paths: remember that the definition specifies that all paths between def-use pairs must be executed, modulo loops. So you'd need to ensure for example that for the (C,JK) pair with respect to variable j, that paths **CEJK**, **CEGJK**, **CEGHEJK**, and **CEGHEGJK** are covered. This is clearly a lot of work, and not something I'm about to ask you to do...