Intro to Software Testing
Chapter 8.1.2

Logic Coverage

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SWE 437

Adapted from slides by Paul Ammann & Jeff Offutt
Combinatorial Coverage

This is simple, neat, clean, and comprehensive ...  
But can be **expensive**  
– Impractical for predicates with more than 3 or 4 clauses  
The literature has lots of suggestions – some confusing  
The general idea is simple:  

**Test each clause independently from the other clauses**  

Getting the details right is hard  
What exactly does “independently” mean?  
The book presents this idea as “**making clauses active**" ...
Active Clauses (8.1.2)

Clause coverage has a **weakness**: The values do not always make a difference.

Consider the CC tests for $P = (a \& (b \mid c))$:

- **Test 1**: $(true \& (true \mid true))$
- **Test 2**: $(false \& (false \mid false))$

Clauses $b$ and $c$ are ignored!

To really test the results of a clause, the clause should be the **determining factor** in the value of the predicate.
Active Clauses

**Determination**

Clause $c_i$ determines the value of its predicate when the other clauses have certain values.

If $c_i$ is changed, the value of the predicate changes.

$c_i$ is called the *major clause*.

Other clauses are *minor clauses*.

This is called *making the clause active*.
Determining Predicates

- **Goal**: Find tests for each clause when the clause determines the value of the predicate

- This is formalized in a *family of criteria* that have subtle, but very important, differences

<table>
<thead>
<tr>
<th>$P = A \lor B$</th>
<th>$P = A \land B$</th>
</tr>
</thead>
<tbody>
<tr>
<td>if $B = true$, $p$ is always true.</td>
<td>if $B = false$, $p$ is always false.</td>
</tr>
<tr>
<td>so if $B = false$, $A$ determines $p$.</td>
<td>so if $B = true$, $A$ determines $p$.</td>
</tr>
<tr>
<td>if $A = false$, $B$ determines $p$.</td>
<td>if $A = true$, $B$ determines $p$.</td>
</tr>
</tbody>
</table>
In-Class Exercise

Making clauses active

\[ P = (a \& (b \mid c)) \]

Write truth values for \( b \) and \( c \) that make clause \( a \) active
For example: \( P_a : b=?? \) or \( c=?? \)
Write truth values for \( a \) and \( c \) that make clause \( b \) active
Write truth values for \( a \) and \( b \) that make clause \( c \) active
In-Class Exercise

Making clauses active

\[ P = (a \& (b \mid c)) \]

Write truth values for \( b \) and \( c \) that make clause \( a \) active
For example: \( Pa : b=?? \) or \( c=?? \)
Write truth values for \( a \) and \( c \) that make clause \( b \) active
Write truth values for \( a \) and \( b \) that make clause \( c \) active

\[
\begin{align*}
Pa &: (b=true \text{ or } c=true) \\
\text{compactly: (b or c)} \\
Pb &: (a \text{ and } !c) \\
Pc &: (a \text{ and } !b)
\end{align*}
\]
Active Clause Coverage

Active Clause Coverage (ACC): For each clause $c_i$ in each predicate $p$, choose values for the other clauses to make $c_i$ active

Create two tests, one where $c_i$ evaluates to true and the other where $c_i$ evaluates to false

- This is a form of MCDC, which is required by the FAA for safety critical software
ACC Ambiguity

Do the minor clauses have to have the same values for both tests?
- Restricted ACC: They do
- Correlated ACC: They do not, but the predicate has to have different values
- General ACC: They do not, and the predicate does not have to have different values either

The FAA requires **MCDC** (modified condition decision coverage) for flight critical software
- Original definition of MCDC was GACC
- For years, some inspectors required RACC, some CACC
- **MCDC is now equivalent to CACC**
- We are skipping GACC and RACC
### CACC Example

|   | a | b | c | a & (b | c) |
|---|---|---|---|---------|
| 1 | T | T | T | T       |
| 2 | T | T | F | T       |
| 3 | T | F | T | T       |
| 4 | T | F | T | T       |
| 5 | F | T | T | F       |
| 6 | F | T | F | F       |
| 7 | F | F | T | F       |
| 8 | F | F | F | F       |

For **a** to determine the value of the predicate

\[ P_a : b=true \text{ or } c = true \]

So we can use ANY OF the 9 pair of rows: (1,5), (1,6), (1,7), (2,5),(2,6),(2,7), (3,5),(3,6),(3,7)

For **b** to determine the value of the predicate

\[ P_b : a=true \text{ and } c = false \]

Rows 2 and 4

For **c** to determine the value of the predicate

\[ P_c : a=true \text{ and } b = false \]

Rows 3 and 4
In-Class Exercise
Making clauses active

\[ P = ((a \& b) \mid c \mid (d \& e)) \]

Pick any one of the 5 clauses
Call it \textbf{ci}
Solve for \textbf{ci}
Answer by giving truth values for the other 4 clauses that make your \textbf{ci} determine the value of the predicate
In-Class Exercise

Making clauses active

P = ((a\&b) | c | (d\&e))

Pick any one of the 5 clauses
Call it ci
Solve for ci
Answer by giving truth values for the other 4 clauses that make your ci determine the value of the predicate P = ((a\&b) | c | (d\&e))

Pa = b and !c and !(d and e)
   = b and !c and (!d or !e)
Pb = a and !c and !(d and e)
   = a and !c and (!d or !e)
Pc = !(a and b) and !(d and e)
   = (!a or !b) and (!d or !b)
Pd = !(a and b) and !c and e
   = (!a or !b) and !c and e
Pe = !(a and b) and !c and d
   = (!a or !b) and !c and d