SWE 637 Software Testing
Chapter 9

In-class exercise

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(Dr. B for short)

https://go.gmu.edu/SWE637

Adapted from slides by Jeff Offutt and Bob Kurtz

Exercise 8.3 #12

```
public final class GoodFastCheap {
  boolean good = false;
  boolean fast = false;
  boolean cheap = false;

  public void makeGood () {
    good = true;
    if (fast && cheap) cheap = false;
  }

  public void makeFast () {
    fast = true;
    if (good && cheap) good = false;
  }

  public void makeCheap () {
    cheap = true;
    if (good && fast) fast = false;
  }

  public void makeBad () { good = false };
  public void makeSlow () { fast = false };
  public void makeExpensive () { cheap = false; }

  public boolean isSatisfactory () {
    if ((good && fast) || (good && cheap) || (fast && cheap))
      return true;
    return false;
  }

  public boolean isSatisfactoryRefactored () {
    if (good && fast) return true;
    if (good && cheap) return true;
    if (fast && cheap) return true;
    return false;
  }
}
```

Good, fast, and cheap: pick any two out of three!

Mutating GoodFastCheap

```
public boolean isSatisfactoryRefactored () {
   if (good && fast) return true;
   if (good && cheap) return true;
   if (fast && cheap) return true;
   return false;
}
```

Consider a mutation operator that replaces each instance of a boolean *variable* with the boolean literals **true** and **false**

1. How many mutants does this operator generate for method isSatisfactory()?
2. List them (just the mutated line, not the whole method) using the Δ1.. ΔN format

Mutating `GoodFastCheap`

Consider a mutation operator that replaces each instance of a boolean *variable* with the boolean literals **true** and **false**

1. How many mutants does this operator generate for method isSatisfactory()?
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Mutating `GoodFastCheap`

Consider a mutation operator that replaces each instance of a boolean *variable* with the boolean literals **true** and **false.**

How many mutants does this operator generate for method isSatisfactory()?

12 mutants

A Mutated GoodFastCheap

12 mutants

```
public final class GoodFastCheap {
  ...

  public boolean isSatisfactory () {
      if ((good && fast) || (good && cheap) || (fast && cheap))
Δ1    if ((true && fast) || (good && cheap) || (fast && cheap))
Δ2    if ((false && fast) || (good && cheap) || (fast && cheap))
Δ3    if ((good && true) || (good && cheap) || (fast && cheap))
Δ4    if ((good && false) || (good && cheap) || (fast && cheap))
Δ5    if ((good && fast) || (true && cheap) || (fast && cheap))
Δ6    if ((good && fast) || (false && cheap) || (fast && cheap))
Δ7    if ((good && fast) || (good && true) || (fast && cheap))
Δ8    if ((good && fast) || (good && false) || (fast && cheap))
Δ9    if ((good && fast) || (good && cheap) || (true && cheap))
Δ10   if ((good && fast) || (good && cheap) || (false && cheap))
Δ11   if ((good && fast) || (good && cheap) || (fast && true))
Δ12   if ((good && fast) || (good && cheap) || (fast && false))
          return true;
      return false;
  }
}
```

Strong Killing Mutants

Which mutants are strongly killed by test TTF (good=T,fast=T,cheap=F)?

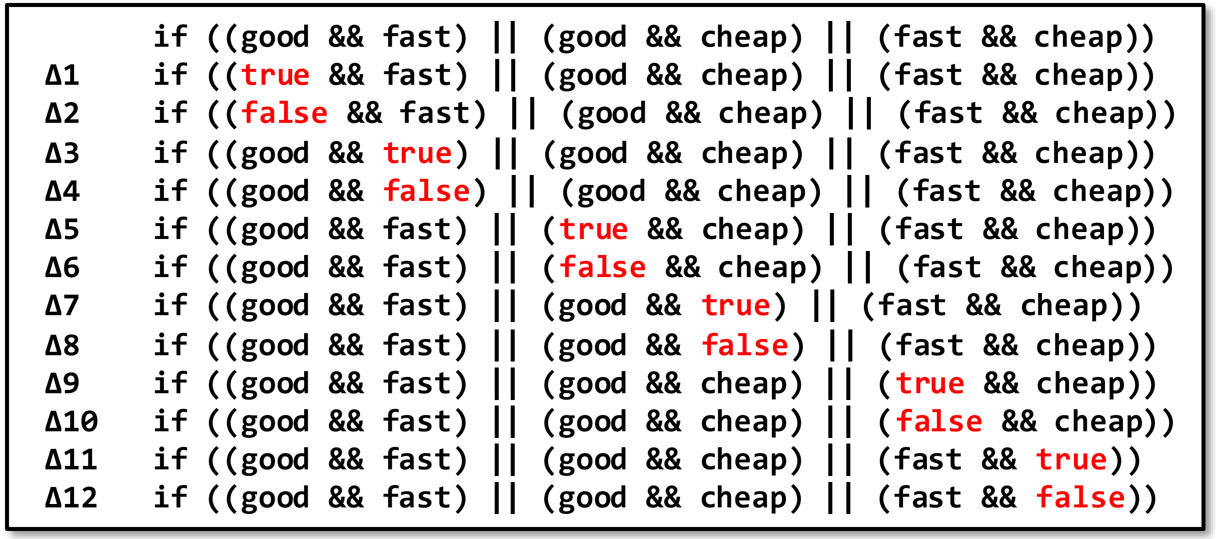
```
       if ((good && fast) || (good && cheap) || (fast && cheap))
Δ1     if ((true && fast) || (good && cheap) || (fast && cheap))
Δ2     if ((false && fast) || (good && cheap) || (fast && cheap))
Δ3     if ((good && true) || (good && cheap) || (fast && cheap))
Δ4     if ((good && false) || (good && cheap) || (fast && cheap))
Δ5     if ((good && fast) || (true && cheap) || (fast && cheap))
Δ6     if ((good && fast) || (false && cheap) || (fast && cheap))
Δ7     if ((good && fast) || (good && true) || (fast && cheap))
Δ8     if ((good && fast) || (good && false) || (fast && cheap))
Δ9     if ((good && fast) || (good && cheap) || (true && cheap))
Δ10    if ((good && fast) || (good && cheap) || (false && cheap))
Δ11    if ((good && fast) || (good && cheap) || (fast && true))
Δ12    if ((good && fast) || (good && cheap) || (fast && false))
```

Strong Killing Mutants

Which mutants are strongly killed by test TTF (good=T,fast=T,cheap=F)?

2, 4

Which mutants are strongly killed by test TFT?



```
       if ((good && fast) || (good && cheap) || (fast && cheap))
Δ1     if ((true && fast) || (good && cheap) || (fast && cheap))
Δ2     if ((false && fast) || (good && cheap) || (fast && cheap))
Δ3     if ((good && true) || (good && cheap) || (fast && cheap))
Δ4     if ((good && false) || (good && cheap) || (fast && cheap))
Δ5     if ((good && fast) || (true && cheap) || (fast && cheap))
Δ6     if ((good && fast) || (false && cheap) || (fast && cheap))
Δ7     if ((good && fast) || (good && true) || (fast && cheap))
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Δ11    if ((good && fast) || (good && cheap) || (fast && true))
Δ12    if ((good && fast) || (good && cheap) || (fast && false))
```

Strong Killing Mutants

Which mutants are strongly killed by test TTF (good=T,fast=T,cheap=F)?

2, 4

Which mutants are strongly killed by test TFT?

6, 8

Which mutants are strongly killed by test FFF?

```
        if ((good && fast) || (good && cheap) || (fast && cheap))
Δ1      if ((true && fast) || (good && cheap) || (fast && cheap))
Δ2      if ((false && fast) || (good && cheap) || (fast && cheap))
Δ3      if ((good && true) || (good && cheap) || (fast && cheap))
Δ4      if ((good && false) || (good && cheap) || (fast && cheap))
Δ5      if ((good && fast) || (true && cheap) || (fast && cheap))
Δ6      if ((good && fast) || (false && cheap) || (fast && cheap))
Δ7      if ((good && fast) || (good && true) || (fast && cheap))
Δ8      if ((good && fast) || (good && false) || (fast && cheap))
Δ9      if ((good && fast) || (good && cheap) || (true && cheap))
Δ10     if ((good && fast) || (good && cheap) || (false && cheap))
Δ11     if ((good && fast) || (good && cheap) || (fast && true))
Δ12     if ((good && fast) || (good && cheap) || (fast && false))
```

Strong Killing Mutants

Which mutants are strongly killed by test TTF (good=T,fast=T,cheap=F)?

2, 4

Which mutants are strongly killed by test TFT?

6, 8

Which mutants are strongly killed by test FFF?

None

Determine a test to kill each mutant. Are any of the mutants equivalent?

```
      if ((good && fast) || (good && cheap) || (fast && cheap))
Δ1    if ((true && fast) || (good && cheap) || (fast && cheap))
Δ2    if ((false && fast) || (good && cheap) || (fast && cheap))
Δ3    if ((good && true) || (good && cheap) || (fast && cheap))
Δ4    if ((good && false) || (good && cheap) || (fast && cheap))
Δ5    if ((good && fast) || (true && cheap) || (fast && cheap))
Δ6    if ((good && fast) || (false && cheap) || (fast && cheap))
Δ7    if ((good && fast) || (good && true) || (fast && cheap))
Δ8    if ((good && fast) || (good && false) || (fast && cheap))
Δ9    if ((good && fast) || (good && cheap) || (true && cheap))
Δ10   if ((good && fast) || (good && cheap) || (false && cheap))
Δ11   if ((good && fast) || (good && cheap) || (fast && true))
Δ12   if ((good && fast) || (good && cheap) || (fast && false))
```

Strong Killing Mutants

Which mutants are strongly killed by test TTF (good=T,fast=T,cheap=F)?

2, 4

Which mutants are strongly killed by test TFT?

6, 8

Which mutants are strongly killed by test FFF?

None

Determine a test to kill each mutant. Are any of the mutants equivalent?

No, all mutants are strongly killed by exactly one test

m1 FTF, m2 TTF, m3 TFF, m4 TTF, m5 FFT, m6 TFT, m7 TFF, m8 TFT, m9 FFT, m10 FTT, m11 FTF, m12 FTT

Weakly Killing Mutants

Does any test kill m1 weakly but not strongly?

```
   if ((good && fast) || (good && cheap) || (fast && cheap))
Δ1  if ((true && fast) || (good && cheap) || (fast && cheap))
```

FTT weakly kills m1

(true && fast) is true, so (good && cheap) and (fast && cheap) are never evaluated (which weakly kills m1 based on an error in the PC), but the result is the same as for P so m1 is not strongly killed

END OF EXERCISE

Mutating GoodFastCheap

```
public boolean isSatisfactoryRefactored () {
   if (good && fast) return true;
   if (good && cheap) return true;
   if (fast && cheap) return true;
   return false;
}
```

Consider a conditional operator replacement (COR) mutation operator that replaces each instance of a conditional operator { &&, || } with the other, **and also** replaces the entire conditional expression (the operator and both operands) with true and false.

1. How many mutants does this operator generate for method isSatisfactoryRefactored()?
2. List them (just the mutated line, not the whole method) using the Δ1.. ΔN format

Another Mutated GoodFastCheap

9 mutants

```
public final class GoodFastCheap {
  ...

  public boolean isSatisfactoryRefactored () {
      if (good && fast) return true;
Δ1    if (good || fast) return true;
Δ2    if (true) return true;
Δ3    if (false) return true;
      if (good && cheap) return true;
Δ4    if (good || cheap) return true;
Δ5    if (true) return true;
Δ6    if (false) return true;
      if (fast && cheap) return true;
Δ7    if (fast || cheap) return true;
Δ8     if (true) return true;
Δ9     if (false) return true;
      return false;
}
```

Another Mutated GoodFastCheap

Determine a test to strongly kill each mutant (gfc)

```
     if (good && fast) return true;
Δ1     if (good || fast) return true;      // Killed by:
Δ2     if (true) return true;              // Killed by:
Δ3     if (false) return true;             // Killed by:

       if (good && cheap) return true;
Δ4     if (good || cheap) return true;     // Killed by:
Δ5     if (true) return true;              // Killed by:
Δ6     if (false) return true;             // Killed by:

       if (fast && cheap) return true;
Δ7     if (fast || cheap) return true;     // Killed by:
Δ8      if (true) return true;             // Killed by:
Δ9      if (false) return true;            // Killed by:
```

Another Mutated GoodFastCheap

Determine a test to strongly kill each mutant (gfc)

```
    if (good && fast) return true;
Δ1    if (good || fast) return true;      // Killed by: TFF,FTF
Δ2    if (true) return true;              // Killed by: FFF,TFF,FTF,FFT
Δ3    if (false) return true;             // Killed by: TTF

      if (good && cheap) return true;
Δ4    if (good || cheap) return true;     // Killed by:
Δ5    if (true) return true;              // Killed by:
Δ6    if (false) return true;             // Killed by:

      if (fast && cheap) return true;
Δ7    if (fast || cheap) return true;     // Killed by:
Δ8     if (true) return true;             // Killed by:
Δ9     if (false) return true;            // Killed by:
```

Another Mutated GoodFastCheap

Determine a test to strongly kill each mutant (gfc)

```
     if (good && fast) return true;
Δ1    if (good || fast) return true;      // Killed by: TFF,FTF
Δ2    if (true) return true;              // Killed by: FFF,TFF,FTF,FFT
Δ3    if (false) return true;             // Killed by: TTF

      if (good && cheap) return true;
Δ4    if (good || cheap) return true;     // Killed by: TFF,FFT
Δ5    if (true) return true;              // Killed by: FFF,TFF,FTF,FFT
Δ6    if (false) return true;             // Killed by: TFT

      if (fast && cheap) return true;
Δ7    if (fast || cheap) return true;     // Killed by:
Δ8     if (true) return true;             // Killed by:
Δ9     if (false) return true;            // Killed by:
```

Another Mutated GoodFastCheap

Determine a test to strongly kill each mutant (gfc)

```
    if (good && fast) return true;
Δ1    if (good || fast) return true;        // Killed by: TFF,FTF
Δ2    if (true) return true;                // Killed by: FFF,TFF,FTF,FFT
Δ3    if (false) return true;               // Killed by: TTF

      if (good && cheap) return true;
Δ4    if (good || cheap) return true;       // Killed by: TFF,FFT
Δ5    if (true) return true;                // Killed by: FFF,TFF,FTF,FFT
Δ6    if (false) return true;               // Killed by: TFT

      if (fast && cheap) return true;
Δ7    if (fast || cheap) return true;       // Killed by: FTF,FFT
Δ8     if (true) return true;               // Killed by: FFF,TFF,FTF,FFT
Δ9     if (false) return true;              // Killed by: FTT
```