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Control Flow, Conditional Statements and Loops

Correctly Organizing the Control Flow Logic

Telerik Software Academy
Learning & Development
http://academy.telerik.com

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Organizing Straight-Line Code

Order and Separate Your Dependencies Correctly

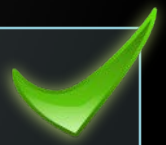
Straight-Line Code

- When statements' order matters

```
GetData();
GroupData();
Print();
```

  - Make dependencies obvious
  - Name methods according to dependencies
  - Use method parameters

```
data = GetData();
groupedData = GroupData(data);
PrintGroupedData(groupedData);
```



  - Document the control flow if needed

Straight-Line Code (2)

- When statements' order does not matter
  - Make code read from top to bottom like a newspaper
  - Group related statements together
  - Make clear boundaries for dependencies
    - Use blank lines to separate dependencies
    - User separate method

Straight-Line Code – Examples

```
ReportFooter CreateReportFooter(Report report)
{
  // …
}

ReportHeader CreateReportHeader(Report report)
{
  // …
}

Report CreateReport()
{
  var report = new Report();
  report.Footer = CreateReportFooter(report);
  report.Content = CreateReportContent(report);

  report.Header = CraeteReportHeader(report);
  return report;
}

ReportContent CreateReportContent(Report report)
{
  // …
}
```

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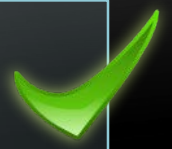
Straight-Line Code – Examples



```
Report CreateReport()
{
  var report = new Report();

  report.Header = CreateReportHeader(report);
  report.Content = CreateReportContent(report);
  report.Footer = CreateReportFooter(report);

  return report;
}

ReportHeader CraeteReportHeader(Report report)
{
  // …
}

ReportContent CreateReportContent(Report report)
{
  // …
}

ReportFooter CreateReportFooter(Report report)
{
  // …
}
```

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Straight-Line Code – Summary

- The most important thing to consider when organizing straight-line code is
  - Ordering dependencies
- Dependencies should be made obvious
  - Through the use of good routine names, parameter lists and comments
- If code doesn't have order dependencies
  - Keep related statements together

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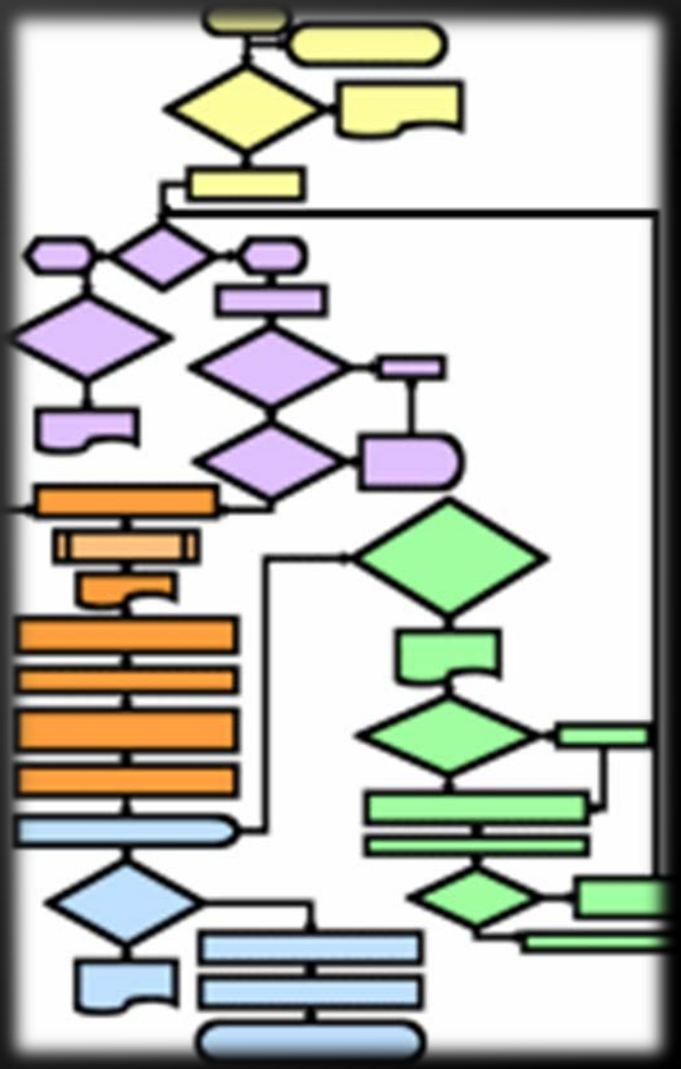
Using Conditional Statements

Using Control Structures



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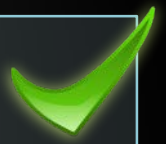
Using Conditional Statements

- Always use { and } for the conditional statements body, even when it is a single line:

```
if (condition)
{
  DoSometing();
}
```



- Why omitting the brackets could be harmful?

```
if (condition)
  DoSomething();
  DoAnotherThing();
DoDifferentThing();
```

  - This is misleading code + misleading formatting

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Using Conditional Statements (2)

- Always put the normal (expected) condition first after the `if` clause

```
var response = GetHttpWebResponse();
if (response.Code == Code.NotFound)
{
  // ...
}
else
{
  if (response.Code == Code.OK)
  {
    // ...
  }
}
```

```
var response = GetHttpWebResponse();
if (response.Code == Code.OK)
{
  // ...
}
else
{
  if (response.Code == Code.NotFound)
  {
    // ...
  }
}
```

- Start from most common cases first, then go to the unusual ones

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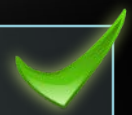
Using Conditional Statements (3)

- Avoid comparing to `true` or `false`:

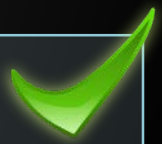
```
if (HasErrors == true)
{
  ...
}
```

```
if (HasErrors)
{
  ...
}
```



- Always consider the else case
  - If needed, document why the else isn't necessary

```
if (parserState != States.Finished)
{
  // …
}
else
{
  // Ignore all content once the pareser has finished
}
```



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Using Conditional Statements (4)

- Avoid double negation

```
if (!HasNoError)
{
  DoSomething();
}
```

```
if (HasErrors)
{
  DoSometing();
}
```

- Write `if` clause with a meaningful statement

```
if (!HasError)
;
else
{
  DoSometing();
}
```

```
if (HasErrors)
{
  DoSometing();
}
```

- Use meaningful boolean expressions, which read like a sentence

Using Conditional Statements (5)

- Be aware of copy/paste problems in `if-else` bodies

```
if (SomeCondition)
{
  var p = GetSomePerson();
  p.SendMail();
  p.SendSms();
}
else
{
  var p = GetOtherPerson();
  p.SendMail();
  p.SendSms();
}
```

```
Person p = null;
if (SomeCondition)
{
  p = GetSomePerson();
}
else
{
  p = GetOtherPerson();
}

p.SendMail();
p.SendSms();
```

Use Simple Conditions

- Do not use complex `if` conditions
  - You can always simplify them by introducing boolean variables or boolean methods
  - Incorrect example:

```
if (x > 0 && y > 0 && x < Width-1 && y < Height-1 &&
  matrix[x, y] == 0 && matrix[x-1, y] == 0 &&
  matrix[x+1, y] == 0 && matrix[x, y-1] == 0 &&
  matrix[x, y+1] == 0 && !visited[x, y]) …
```

  - Complex boolean expressions can be harmful
  - How you will find the problem if you get `IndexOutOfRangeException`?

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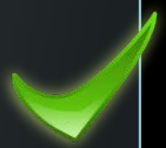
Simplifying Boolean Conditions

- The last example can be easily refactored into self-documenting code:

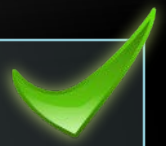
```
bool inRange = x > 0 && y > 0 && x < Width-1 && y < Height-1;
if (inRange)
{
  bool emptyCellAndNeighbours =
    matrix[x, y] == 0 && matrix[x-1, y] == 0 &&
    matrix[x+1, y] == 0 && matrix[x, y-1] == 0 &&
    matrix[x, y+1] == 0;
  if (emptyCellAndNeighbours && !visited[x, y]) …
}
```



- Now the code is:
  - Easy to read – the logic of the condition is clear
  - Easy to debug – breakpoint can be put at the `if`

Simplifying Boolean Conditions (2)

- Use object-oriented approach



```
class Maze
{
  Cell CurrentCell { get; set; }
  IList<Cell> VisitedCells { get; }
  IList<Cell> NeighbourCells { get; }
  Size Size { get; }

  bool IsCurrentCellInRange()
  {
    return Size.Contains(CurrentCell);
  }

  bool IsCurrentCellVisited()
  {
    return VisitedCells.Contains(CurrentCell);
  }
```

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Simplifying Boolean Conditions (3)

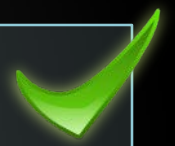
```
  bool AreNeighbourCellsEmpty()
  {
    …
  }

  bool ShouldVisitCurrentCell()
  {
    return
      IsCurrentCellInRange() &&
      CurrentCell.IsEmpty() &&
      AreNeighbourCellsEmpty() &&
      !IsCurrentCellVisited()
  }
}
```

- Now the code:
  - Models the real scenario
  - Stays close to the problem domain

Use Decision Tables

- Sometimes a decision table can be used for simplicity



```
var table = new Hashtable();
table.Add("A", new AWorker());
table.Add("B", new BWorker());
table.Add("C", new CWorker());

string key = GetWorkerKey();

var worker = table[key];
if (worker != null)
{
  ...
  worker.Work();
  ...
}
```

Positive Boolean Expressions

- Starting with a positive expression improves the readability

```
if (IsValid)
{
  DoSometing();
}
else
{
  DoSometingElse();
}
```

```
if (!IsValid)
{
  DoSometingElse();
}
else
{
  DoSomething();
}
```

- Use De Morgan's laws for negative checks

```
if (!IsValid || !IsVisible)
```

=

```
if (!(IsValid && IsVisible))
```

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Use Parentheses for Simplification

- Avoid complex boolean conditions without parenthesis

```
if (a < b && b < c || c == d)
```

- Using parenthesis helps readability as well as ensure correctness

```
if (( a < b && b < c ) || c == d)
```

- Too many parenthesis have to be avoided as well
  - Consider separate Boolean methods or variables in those cases

Boolean Expression Evaluation

- Most languages evaluate from left to right
  - Stop evaluation as soon as some of the boolean operands is satisfied

```
if (FalseCondition && OtherCondition)
```
= false

```
if (TrueCondition || OtherCondition)
```
= true

- Useful when checking for `null`

```
if (list != null && list.Count > 0) …
```

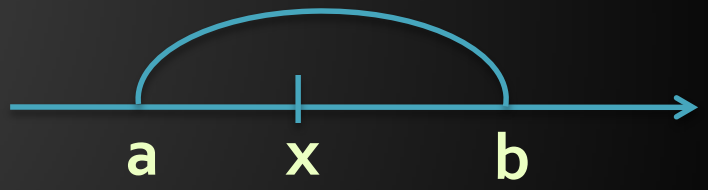
- There are languages that does not follow this "short-circuit" rule

Numeric Expressions as Operands

- Write numeric boolean expressions as they are presented on a number line
  - Contained in an interval

```
if (x > a && b > x)
```

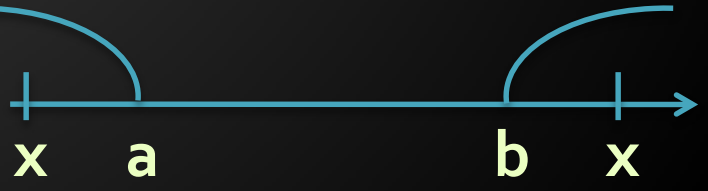
```
if (a < x && x < b)
```



  - Outside of an interval

```
if (a > x || x > b)
```

```
if (x < a || b < x)
```



Avoid Deep Nesting of Blocks

- Deep nesting of conditional statements and loops makes the code unclear
  - More than 2-3 levels is too deep
  - Deeply nested code is complex and hard to read and understand
  - Usually you can extract portions of the code in separate methods
    - This simplifies the logic of the code
    - Using good method name makes the code self-documenting

Deep Nesting – Example

```
if (maxElem != Int32.MaxValue)
{
    if (arr[i] < arr[i + 1])
    {
        if (arr[i + 1] < arr[i + 2])
        {
            if (arr[i + 2] < arr[i + 3])
            {
                maxElem = arr[i + 3];
            }
            else
            {
                maxElem = arr[i + 2];
            }
        }
        else
        {
            if (arr[i + 1] < arr[i + 3])
            {
                maxElem = arr[i + 3];
            }
            else
            {
                maxElem = arr[i + 1];
            }
        }
    }
```

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Deep Nesting – Example (2)

```
    else
    {
        if (arr[i] < arr[i + 2])
        {
            if (arr[i + 2] < arr[i + 3])
            {
                maxElem = arr[i + 3];
            }
            else
            {
                maxElem = arr[i + 2];
            }
        }
        else
        {
            if (arr[i] < arr[i + 3])
            {
                maxElem = arr[i + 3];
            }
            else
            {
                maxElem = arr[i];
            }
        }
    }
}
```

Avoiding Deep Nesting – Example

```
private static int Max(int i, int j)
{
    if (i < j)
    {
        return j;
    }
    else
    {
       return i;
    }
}

private static int Max(int i, int j, int k)
{
    if (i < j)
    {
        int maxElem = Max(j, k);
        return maxElem;
    }
    else
    {
        int maxElem = Max(i, k);
        return maxElem;
    }
}
```

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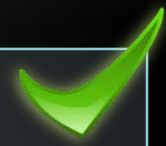
Avoiding Deep Nesting – Example (2)



```
private static int FindMax(int[] arr, int i)
{
  if (arr[i] < arr[i + 1])
  {
    int maxElem = Max(arr[i + 1], arr[i + 2], arr[i + 3]);
    return maxElem;
  }
  else
  {
    int maxElem = Max(arr[i], arr[i + 2], arr[i + 3]);
    return maxElem;
  }
}

if (maxElem != Int32.MaxValue) {
  maxElem = FindMax(arr, i);
}
```

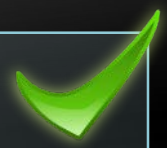
Using Case Statement

- Choose the most effective ordering of cases
  - Put the normal (usual) case first
  - Order cases by frequency
  - Put the most unusual (exceptional) case last
  - Order cases alphabetically or numerically
- Keep the actions of each case simple
  - Extract complex logic in separate methods
- Use the default clause in a `case` statement or the last `else` in a chain of `if-else` to trap errors

Incorrect Case Statement

```
void ProcessNextChar(char ch)
{
  switch (parseState)
  {
    case InTag:
      if (ch == ">")
      {
        Console.WriteLine("Found tag: {0}", tag);
        text = "";
        parseState = ParseState.OutOfTag;
      }
      else
      {
        tag = tag + ch;
      }
      break;
    case OutOfTag:
      …
  }
}
```

Improved Case Statement



```
void ProcessNextChar(char ch)
{
  switch (parseState)
  {
    case InTag:
      ProcessCharacterInTag(ch);
      break;
    case OutOfTag:
      ProcessCharacterOutOfTag(ch);
      break;
    default:
      throw new InvalidOperationException(
        "Invalid parse state: " + parseState);
  }
}
```

Case – Best Practices

- Avoid using fallthroughs
- When you do use them, document them well

```
switch (c)
{
  case 1:
  case 2:
    DoSomething();
    // FALLTHROUGH
  case 17:
    DoSomethingElse();
    break;
  case 5:
  case 43:
    DoOtherThings();
    break;
}
```

Case – Best Practices(2)

- Overlapping control structures is evil:

```
switch (inputVar)
{
  case 'A': if (test)
            {
              // statement 1
              // statement 2
  case 'B':   // statement 3
              // statement 4
              ...
            }
            ...
            break;
}
```

- This code will not compile in C# but may compile in other languages

Control Statements – Summary

- For simple if-else-s, pay attention to the order of the `if` and `else` clauses
  - Make sure the nominal case is clear
- For if-then-else chains and case statements, choose the most readable order
- Optimize boolean statements to improve readability
- Use the default clause in a case statement or the last else in a chain of if-s to trap errors

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Using Loops

Choose Appropriate Loop Type and Don't Forget to Break

Using Loops

- Choosing the correct type of loop:
  - Use `for` loop to repeat some block of code a certain number of times
  - Use `foreach` loop to process each element of an array or a collection
  - Use `while` / `do-while` loop when you don't know how many times a block should be repeated
- Avoid deep nesting of loops
  - You can extract the loop body in a new method

Loops: Best Practices

- Keep loops simple
  - This helps readers of your code
- Treat the inside of the loop as it were a routine
  - Don't make the reader look inside the loop to understand the loop control
- Think of a loop as a black box:

```
while (!inputFile.EndOfFile() && !hasErrors)
{
    (black box code)
}
```

Loops: Best Practices (2)

- Keep loop's housekeeping at the start or at the end of the loop block

```
while (index < 10)
{
   ...
   index += 2;
   ...
}
```

```
while (index < 10)
{
   ...
   ...
   index += 2;
}
```

- Use meaningful variable names to make loops readable

```
for(i=2000, i<2011, i++)
{
   for(j=1, j<=12, j++)
   ...
}
```

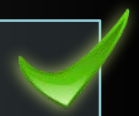
```
for (year=2000, year<2011, year++)
{
   for(month=1, month<=12, month++)
   ...
}
```

Loops: Best Practices (3)

- Avoid empty loops

```
while ((inputChar = Console.Read()) != '\n')
{
}
```

```
do
{
    inputChar = Console.Read();
}
while (inputChar != '\n');
```



- Be aware of your language (loop) semantics
  - C# – access to modified closure

Loops: Tips on for-Loop

- Don't explicitly change the index value to force the loop to stop
  - Use `while`-loop with `break` instead
- Put only the controlling statements in the loop header

```
for (i = 0, sum = 0;
  i < length;
  sum += arr[i], i++)
{
    ;
}
```

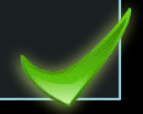
```
sum = 0;
for (i = 0; i < length; i++)
{
    sum += arr[i];
}
```

Loops: Tips on for-Loop(2)

- Avoid code that depends on the loop index's final value

```
for (i = 0; i < length; i++)
{
  if (array[i].id == key)
  {
    break;
  }
}

// Lots of code
...

return (i >= length);
```

```
bool found = false;
for (i = 0; i < length; i++)
{
  if (array[i].id == key)
  {
    found = true;
    break;
  }
}

// Lots of code
...

return found;
```

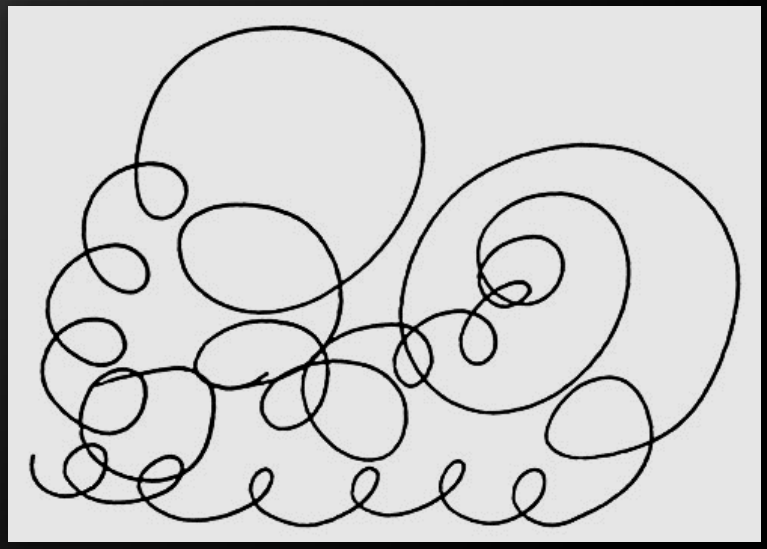


Loops: break and continue

- Use `continue` for tests at the top of a loop to avoid nested `if`-s
- Avoid loops with lots of `brake`-s scattered trough it
- Use `break` and `continue` only with caution

How Long Should a Loop Be?

- Try to make the loops short enough to view it all at once (one screen)
- Use methods to shorten the loop body
- Make long loops especially clear
- Avoid deep nesting in loops



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Other Control Flow Structures

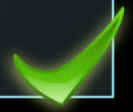
To Understand Recursion, One Must First Understand Recursion

The return Statement

- Use return when it enhances readability
- Use return to avoid deep nesting

```
void ParseString(string str)
{
  if (string != null)
  {
    // Lots of code
  }
}
```

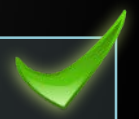
```
void ParseString(string str)
{
  if (string == null)
  {
    return;
  }

  // Lots of code
}
```



- Avoid multiple return-s in long methods

Recursion

- Useful when you want to walk a tree / graph-like structures
- Be aware of infinite recursion or indirect recursion
- Recursion example:



```
void PrintWindowsRecursive(Window w)
{
  w.Print()
  foreach(childWindow in w.ChildWindows)
  {
     PrintWindowsRecursive(childWindow);
  }
}
```

Recursion Tips

- Ensure that recursion has end
- Verify that recursion is not very high-cost
  - Check the occupied system resources
  - You can always use stack classes and iteration
- Don't use recursion when there is better linear (iteration based) solution, e.g.
  - Factorials
  - Fibonacci numbers
- Some languages optimize tail-call recursions

GOTO

- Avoid goto-s, because they have a tendency to introduce spaghetti code
- "A Case Against the GO TO Statement" by Edsger Dijkstra

- Use goto-s as a last resort
  - If they make the code more maintainable
- C# supports goto with labels, but avoid it!

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Control Flow, Conditional Statements and Loops

http://academy.telerik.com

Homework (1)

1. Refactor the following class using best practices for organizing straight-line code:

```
public void Cook()
public class Chef
{
    private Bowl GetBowl()
    {
        //...
    }
    private Carrot GetCarrot()
    {
        //...
    }
    private void Cut(Vegetable potato)
    {
        //...
    }
                                    // continue on the next slide
```

Homework (2)

```
    public void Cook()
    {
        Potato potato = GetPotato();
        Carrot carrot = GetCarrot();
        Bowl bowl;
        Peel(potato);

        Peel(carrot);
        bowl = GetBowl();
        Cut(potato);
        Cut(carrot);
        bowl.Add(carrot);

        bowl.Add(potato);
    }
    private Potato GetPotato()
    {
        //...
    }
}
```

Homework (3)

2. Refactor the following if statements:

```
Potato potato;
//...
if (potato != null)
   if(!potato.HasNotBeenPeeled && !potato.IsRotten)
      Cook(potato);
```

```
if (x >= MIN_X && (x =< MAX_X && ((MAX_Y >= y &&
MIN_Y <= y) && !shouldNotVisitCell)))
{
   VisitCell();
}
```

Homework (4)

3. Refactor the following loop:

```
int i=0;
for (i = 0; i < 100;)
{
   if (i % 10 == 0)
   {
        Console.WriteLine(array[i]);
        if ( array[i] == expectedValue )
        {
           i = 666;
        }
        i++;
   }
   else
   {
        Console.WriteLine(array[i]);
        i++;
   }
}
// More code here
if (i == 666)
{
    Console.WriteLine("Value Found");
}
```

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