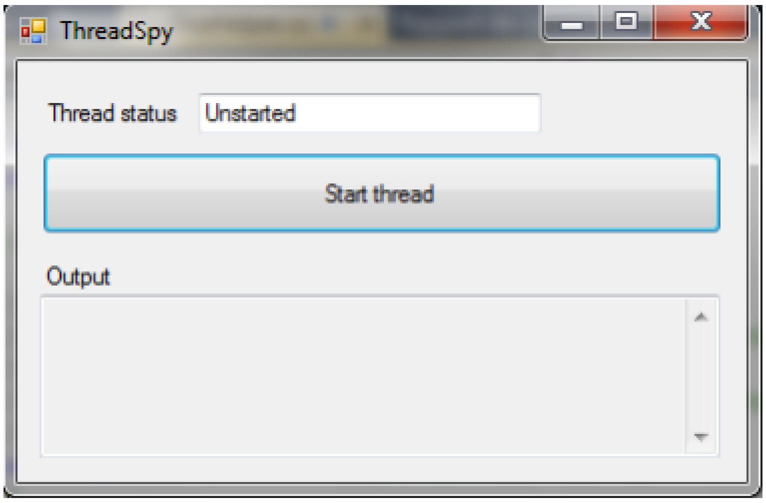
In this lesson, we will use the VB locks and semaphores to synchronize threads. First, we continue with the application of lesson 3. In this application, there can shared variables that are used by multiple threads (this depends on the way in which you programmed the assignment). As we learned this week, this is inherently unsafe, so we have to fix this. a. Identify the shared variables and make sure that they are used in a threadsafe way (this means that always at most one thread at a time is allowed to use these variables). Use locks to do this.

Solution



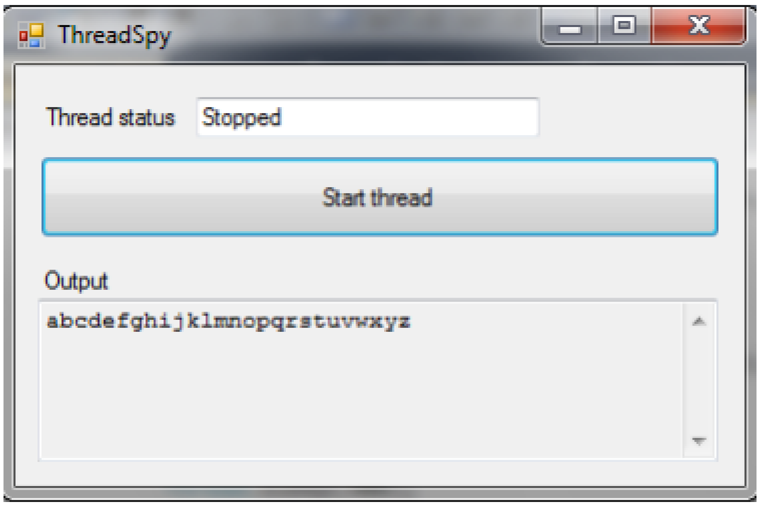
code

```
Imports System.Threading
Imports System.Collections.Generic

Imports System.Text

Imports System.Windows.Forms

namespace ThreadSpy

 class TextBoxHelper

static private TextBox textbox

public delegate sub UpdateTextCallback(char c)


static public sub AddChar(TextBox tbox, char c)

        textbox = tbox

        textbox.Invoke(new UpdateTextCallback(AddCharSave), c)
        end sub
static private sub AddCharSave(char c)
        textbox.Text += c
 end sub
End sub
```

Dans cette application c'est le TextBox textbox qui est partagé.

b. Also, change the program such that at most one thread at a time can put characters in the textbox. Use locks for this also.

Solution



```
Thread status  Stopped
Output
abcdefghijklmnopqrstuvwxyz
```

code cource

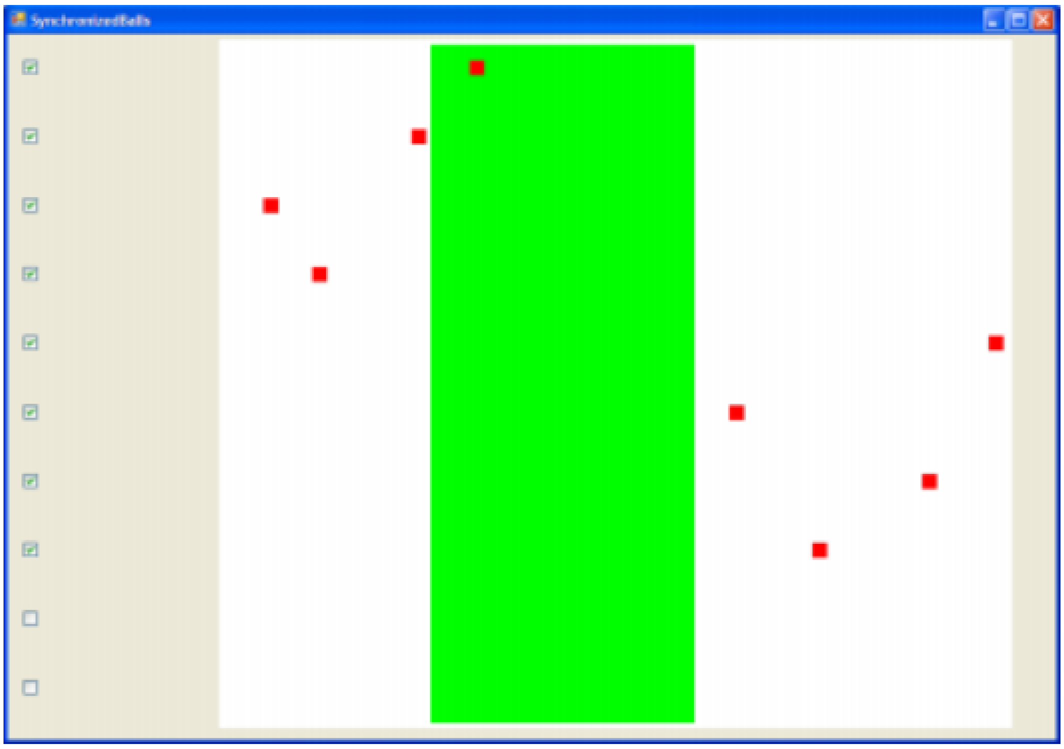
```
public sub Run()
while(true)
        For K As Int = 0 to 1
                Thread.Sleep(300)
                TextBoxHelper.AddChar(md, a)
    Next
        For K As Int = 0 to 1
                Thread.Sleep(300)
                TextBoxHelper.AddChar(md, b)
    Next

        For K As Int = 0 to 1
                Thread.Sleep(300)
                TextBoxHelper.AddChar(md, c)
```

```
Next
    For K As Int = 0 to 1
            Thread.Sleep(300)
            TextBoxHelper.AddChar(md, d)
Next

    For K As Int = 0 to 1
            Thread.Sleep(300)
            TextBoxHelper.AddChar(md, e)
Next

    For K As Int = 0 to 1
            Thread.Sleep(300)
            TextBoxHelper.AddChar(md, f)
Next

    For K As Int = 0 to 1
            Thread.Sleep(300)
            TextBoxHelper.AddChar(md, g)
Next

    For K As Int = 0 to 1
            Thread.Sleep(300)
            TextBoxHelper.AddChar(md, h)
Next

    For K As Int = 0 to 1
            Thread.Sleep(300)
            TextBoxHelper.AddChar(md, i)
Next
    For K As Int = 0 to 1
            Thread.Sleep(300)
            TextBoxHelper.AddChar(md, l)
Next

    For K As Int = 0 to 1
            Thread.Sleep(300)
            TextBoxHelper.AddChar(md, m)
Next

    For K As Int = 0 to 1
            Thread.Sleep(300)
            TextBoxHelper.AddChar(md, n)
```

```
Next
    For K As Int = 0 to 1
            Thread.Sleep(300)
            TextBoxHelper.AddChar(md, o)
Next
    For K As Int = 0 to 1
            Thread.Sleep(300)
            TextBoxHelper.AddChar(md, p)
Next
    For K As Int = 0 to 1
            Thread.Sleep(300)
            TextBoxHelper.AddChar(md, q)
Next
    For K As Int = 0 to 1
            Thread.Sleep(300)
            TextBoxHelper.AddChar(md, r)
Next
    For K As Int = 0 to 1
            Thread.Sleep(300)
            TextBoxHelper.AddChar(md, s)
Next
    For K As Int = 0 to 1
            Thread.Sleep(300)
            TextBoxHelper.AddChar(md, t)
Next
    For K As Int = 0 to 1
            Thread.Sleep(300)
            TextBoxHelper.AddChar(md, u)
Next
    For K As Int = 0 to 1
            Thread.Sleep(300)
            TextBoxHelper.AddChar(md, v)
Next
    For K As Int = 0 to 1
            Thread.Sleep(300)
            TextBoxHelper.AddChar(md, w)
Next
    For K As Int = 0 to 1
            Thread.Sleep(300)
            TextBoxHelper.AddChar(md, x)
Next
    For K As Int = 0 to 1
            Thread.Sleep(300)
```

```
                TextBoxHelper.AddChar(md, y)
    Next
         For K As Int = 0 to 1
                Thread.Sleep(300)
                TextBoxHelper.AddChar(md, z)
    Next

     End sub
```

Next, we use a new application SynchronizedBalls in which the concurrency problems can be shown in a more graphical way. This application has the following screen:



On the left we see 10 checkboxes. Whenever a checkbox is checked, a new thread must be started, that makes a ball move from left to right in the white area. When a checkbox is unchecked the thread must be interrupted. The green area represents the Critical Section, which plays a special role later on. The application has the following classes:

Classe SynchronisationTestForm

```
public partial class SynchronisationTestForm : Form

public const MINI = 0 As Int

public const MAXI = 750 As Int

public const CS_MINI = 200 As Int
public const CS_MAXI = 450 As Int
public PictureBox[] pitbox = new PictureBox[10]
public Thread[] ta = new Thread[10]
public SynchronisationTestForm()
pitbox [0] = pictureBox1
pitbox [1] = pictureBox2
pitbox [2] = pictureBox3
pitbox [3] = pictureBox4
pitbox [4] = pictureBox5
pitbox [5] = pictureBox6
pitbox [6] = pictureBox7
pitbox [7] = pictureBox8
pitbox [8] = pictureBox9
pitbox [9] = pictureBox10
private sub checkBox_CheckedChanged(object sender, EventArgs e)
index As Integer = (((CheckBox)sender).Location.Y - 25) / 65
PictureBox ptb = pitbox [index]
if (((CheckBox)sender).Checked)
End if
else
// The CheckBox was unchecked, so
// the corresponding thread must be interrupted and
// pb must get transparant
background color
End else
End dub
```

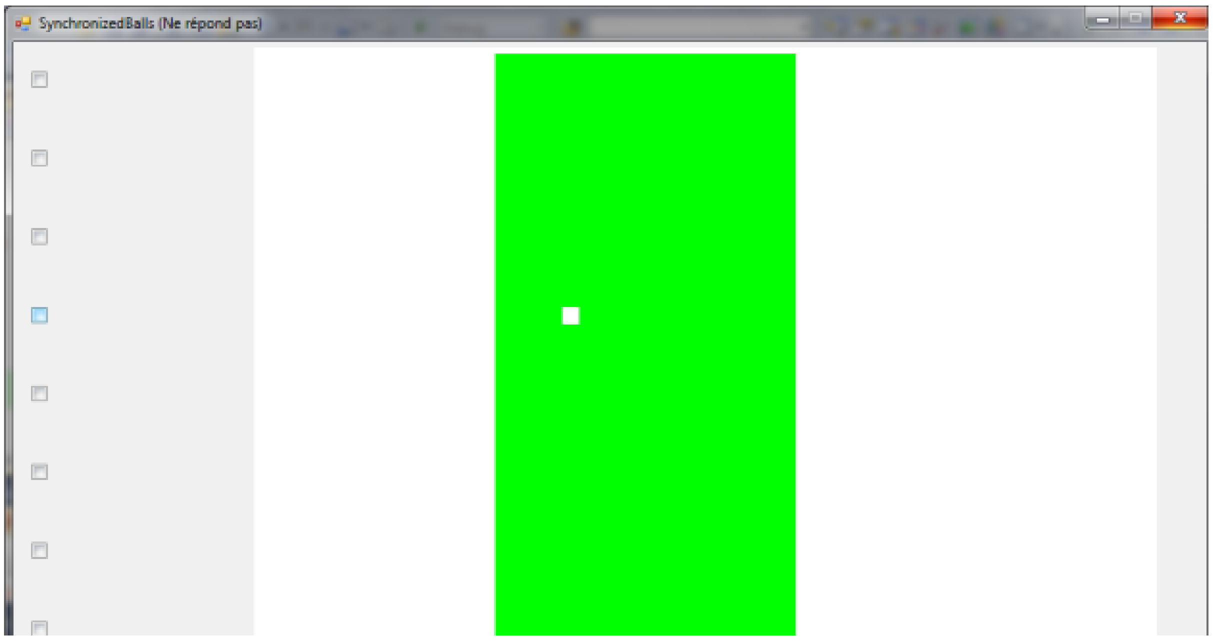
This is the form. Each time when a checkbox changes state, the method checkBox_CheckedChanged is called.

```
Classe BallMov
private delegate sub UpdatePictureBoxCallback(Point p)
private PictureBox pitbox
public BallMov(PictureBox pitbox)
this.pb = pitbox


public sub Run()
try
while (true)
while (pb.Location.X < SynchronisationTestForm.CS_MINI)
DeplaceBall()
Thread.Sleep(10)
loop
while (pb.Location.X < SynchronisationTestForm.CS_MAXI)
DeplaceBall()
Thread.Sleep(10)
loop
while (pb.Location.X < SynchronisationTestForm.MAXI)
DeplaceBall()
Thread.Sleep(10)
loop
ResetBall()
Thread.CurrentThread.Interrupt()
catch (ThreadInterruptedException)
ResetBall()
Return
```

```
End sub


private sub DeplaceBall()
p As Point = pb.Location
p.X++
pb.Invoke(new UpdatePictureBoxCallback(MovePictureBox), p)


public void ResetBall()
p As Point = pb.Location; p.X = SynchronisationTestForm.MINI
pb.Invoke(new UpdatePictureBoxCallback(MovePictureBox), p)
end sub
private sub MovePictureBox(Point p)
pb.Location = p
End sub
End class
```

This class contains the method Run, which is to be executed by every thread. In this method, a ball is moved from left to right on the screen. When the ball is at the far right hand side of the white area, it is placed back to the left hand side. The balls are sll picture boxes.

c. Change the given program such, that the above described behavior is implemented. In order to be able to interrupt a thread when the checkbox is being unchecked, the threads that are created must be put in the array ta, which is already defined in class SynchronisationTestForm. Make sure that all threads stop automatically when the main window is closed.



Code source

private void checkBox_CheckedChanged(object sender, EventArgs e)

// index is the number of the CheckBox that was clicked

// This index is derived from the y-position of the CheckBox

index As Int = (((CheckBox)sender).Location.Y - 25) / 65

// pitbox is the PictureBox that belongs to this CheckBox

PictureBox pitbox = pitbox[index]

if (((CheckBox)sender).Checked)

// The CheckBox was checked, so // pb must get a red background color and // a new thread, that will move pb, must be created and put into ta[index]

// TODO create thread BallMov

ct = new BallMov(pb)

ct.Run()

End if

else

// The CheckBox was unchecked, so // the corresponding thread must be interrupted and // pb must get transparant background color

// TODO interrupt

thread Thread.CurrentThread.Interrupt()

End else

End sub

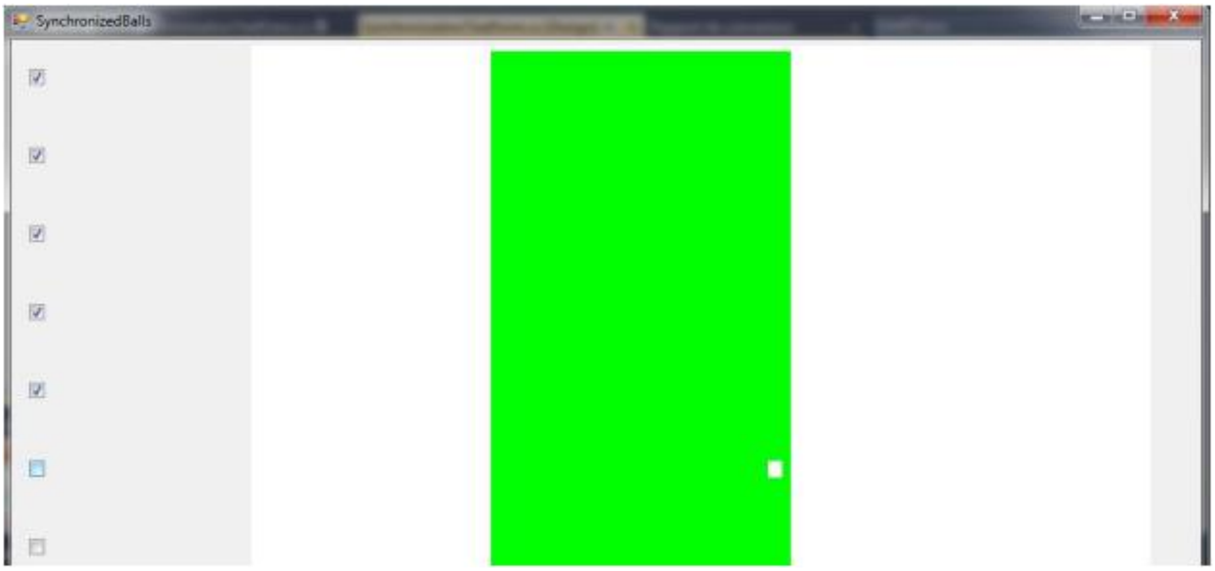
d. Give each ball a randomly chosen speed. This speed must be between roughly 100 and 200 pixels per second (so the Thread.Sleep must be between 5 and 10 msec). You can use class Random for that.

e. Identify which piece of code exactly is the Critical Section.

Solution

```
private sub DeplaceBall()
        p As Point = pb.Location;
        p.X++
pb.Invoke(new UpdatePictureBoxCallback(MovePictureBox), p)
End sub
```

f. Change the program such that at most one thread is in the Critical Section at all times. Use a semaphore for this. Since this semaphore will have to be shared by all threads, create it in the class SynchronisationTestForm, and give the constructor of BallMover an extra argument of type Semaphore (and the class BallMover an extra attribute of type Semaphore) to make it known to the threads also. Make sure it also works well when a thread is interrupted within its Critical Section. Solution

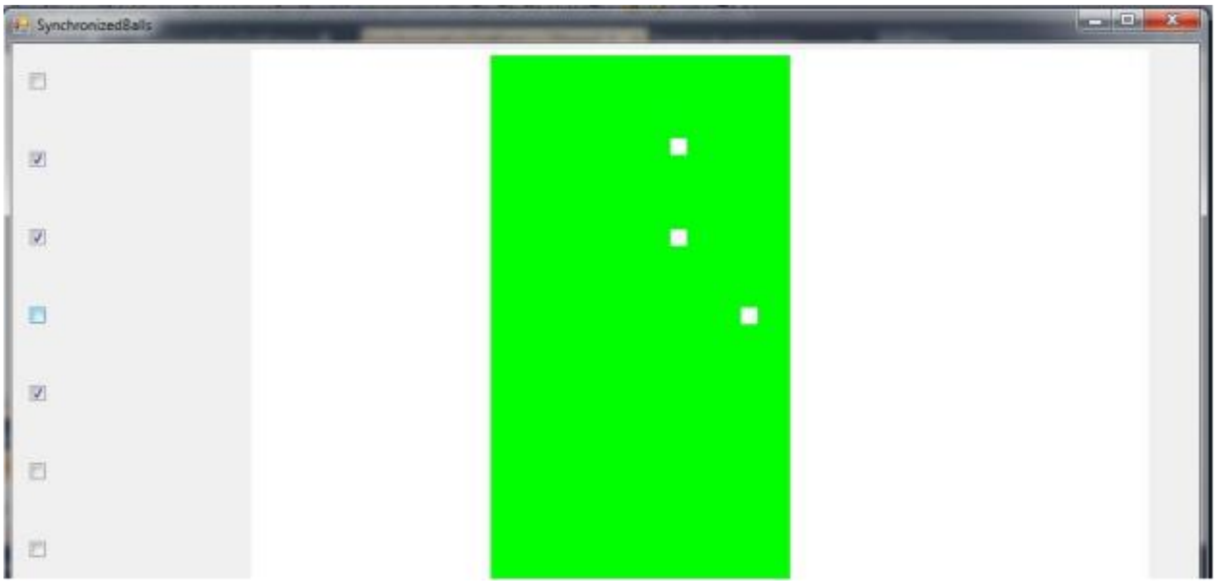


Code source

```
public sub Run()
try
while (true)
while (pb.Location.X < SynchronisationTestForm.CS_MINI)
DeplaceBall()
Thread.Sleep(10)
Next
while (pb.Location.X < SynchronisationTestForm.CS_MAXI)
 DeplaceBall()
Thread.Sleep(10)
 while (pb.Location.X < SynchronisationTestForm.MAXI)
DeplaceBall ()
Thread.Sleep(10)
Next
 ResetBall()
 Thread.CurrentThread.Interrupt()
End sub
catch (ThreadInterruptedException)
 ResetBall()
 return
End sub
```

g. Change the program such that at most three threads are in the Critical Section at all times.

Solution



Code source

```
Imports System
Imports System.Collections.Generic
Imports System.ComponentModel
Imports System.Data
Imports System.Drawing
Imports System.Text
Imports System.Windows.Forms
Imports System.Threading
public partial class SynchronisationTestForm
public const MINI As Int= 3
public const MAXI As Int = 750
public const CS_MINI As Int = 100
public const CS_MAXI As Int = 200
private PictureBox[] pitbox = new PictureBox[10]
private Thread[] ta = new Thread[10]
Random rd
public SynchronisationTestForm()
```

```
pitbox [0] = pictureBox1
pitbox [1] = pictureBox2
pitbox [2] = pictureBox3
pitbox [3] = pictureBox4
pitbox [4] = pictureBox5
pitbox [5] = pictureBox6
pitbox [6] = pictureBox7
pitbox [7] = pictureBox8
pitbox [8] = pictureBox9
pitbox [9] = pictureBox10
private sub checkBox_CheckedChanged(object sender, EventArgs e)
// index is the number of the CheckBox that was clicked
// This index is derived from the y-position of the CheckBox
index As Integer = (((CheckBox)sender).Location.Y - 25) / 65
// pitbox is the PictureBox that belongs to this CheckBox
PictureBox pitbox = pitbox[index]
if (((CheckBox)sender).Checked)
// The CheckBox was checked, so // pb must get a red background color and // a
new thread, that will move pb, must be created and put into
ta[index]
// TODO create thread
 BallMov ct = new BallMov(ptbox)
ct.Run()
End if
else
// The CheckBox was unchecked, so
 // the corresponding thread must be interrupted and
// pitbox must get transparant
```

background color

// TODO interrupt

thread Thread.CurrentThread.Interrupt()

End else

End sub

End class

Save this version.

Now we will implement the readers/writers problem. For that, we need two kinds of threads, which will be represented by two different ball-colors:

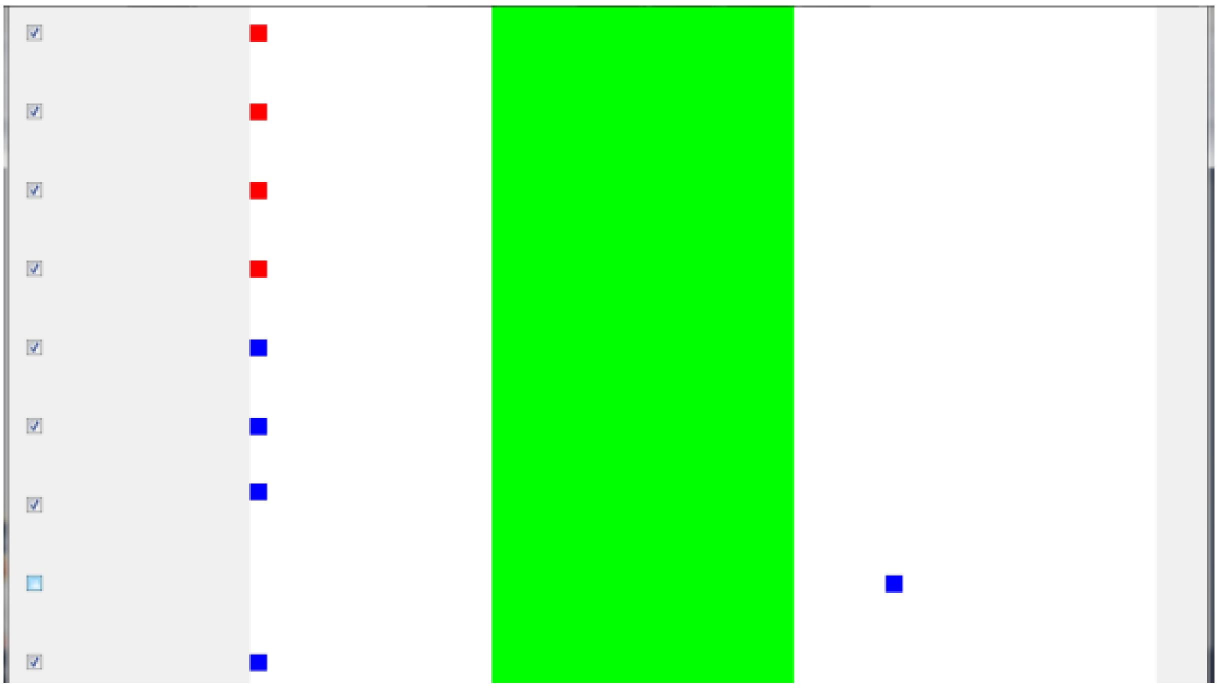
• • red (readers) and

• • blue (writers).

• h. Change the program such that the first 5 balls are red, and the last 5 balls are blue.

• i. Also, use 2 Run-methods inside class BallMover instead of 1. Name them RunReader and RunWriter. Let the red balls execute RunReader and the blue balls execute RunWriter.

Solution



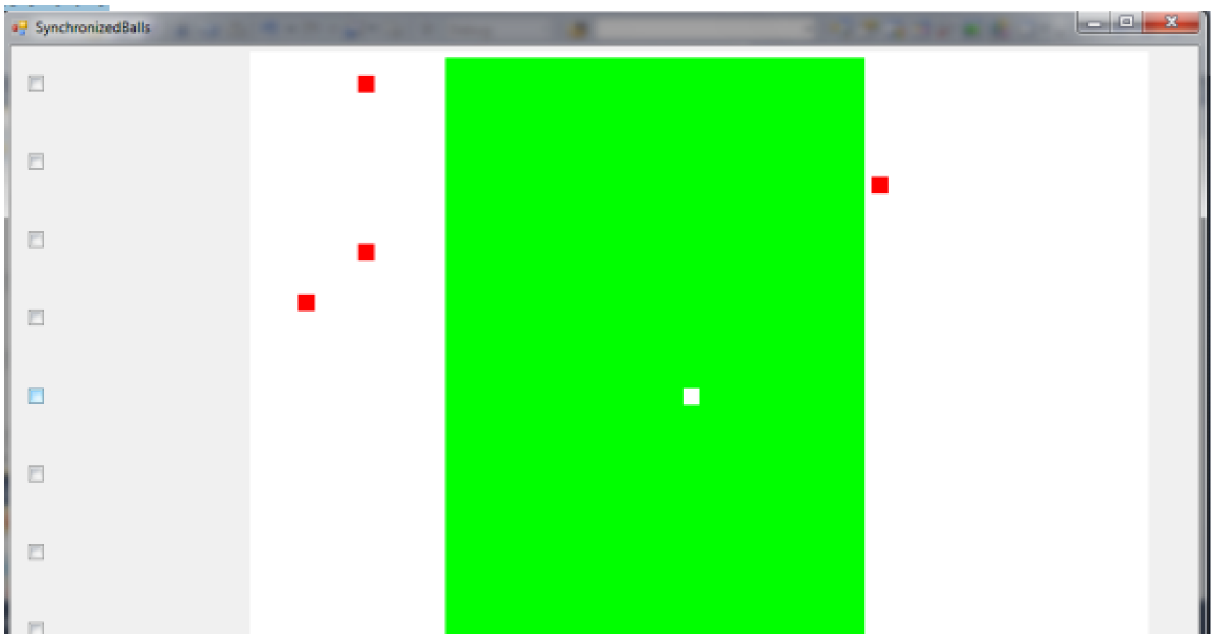
Code source

```
public void RunReader()
pb.BackColor = Color.Red
try
Random rd = new Random(200)
while (true)
 while (pb.Location.X < SynchronisationTestForm.CS_MINI)
DeplaceBall()
 Thread.Sleep(5)
Thread.EndCriticalRegion()
while (pb.Location.X < SynchronisationTestForm.CS_MAXI)
DeplaceBall()
 Thread.Sleep(5)
 Thread.EndCriticalRegion()
 while (pb.Location.X < SynchronisationTestForm.MAXI)
DeplaceBall ()
Thread.Sleep(5)
 Thread.EndCriticalRegion()
Thread.CurrentThread.Interrupt()
 ResetBall()
catch (ThreadInterruptedException)
ResetBall()
return
End sub
public void RunWriter()
pb.BackColor = Color.Blue
try
```

```
Random rd = new Random(200)
while (true)
while (pb.Location.X < SynchronisationTestForm.CS_MINI)
DeplaceBall ()
Thread.Sleep(5)
Thread.EndCriticalRegion()
while (pb.Location.X < SynchronisationTestForm.CS_MAXI)
 DeplaceBall ()
 Thread.Sleep(5)
Thread.EndCriticalRegion()
while (pb.Location.X < SynchronisationTestForm.MAXI)
DeplaceBall ()
Thread.Sleep(5)
 Thread.EndCriticalRegion()
 Thread.CurrentThread.Interrupt()
 ResetBall()
catch (ThreadInterruptedException)
ResetBall()
return
End sub
```

• j. Take the solution for the readers/writers problem that was given in the sheets (using semaphores wrt and mutex, and integer readcount) and make it work in this application. The semaphores can be handled in the same way as in question f. To simplify things, you can assume that a thread will never be stopped inside the green area, so you don’t have to handle this situation.

Solution


SynchronizedBalls