Workbook

Zoe Wall
40182161@napier.ac.uk
Edinburgh Napier University - Fundamentals of Parallel Systems (SET09109)

Exercise 2

2.1 Multiplier Process

Code

Listing 1: "Multiplier.groovy"

```
void run()
{
   def i = inChannel.read()
   while (i > 0) {
      // write i ∗ factor to outChannel
      outChannel.write(i∗factor)
      // read in the next value of i
      i = inChannel.read()
   }
   outChannel.write(i)
}
```

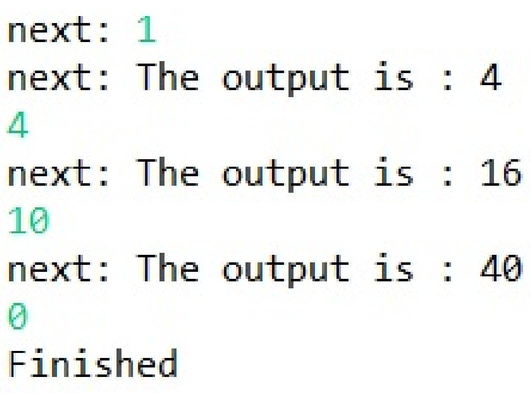
Listing 2: "Consumer.groovy"

```
while ( i > 0 )
{
   //insert a modified println statement
   println "The output is : ${i}"
   i = inChannel.read()
}
```

Listing 3: "RunMultiplier.groovy"

```
def processList = [ new Producer ( outChannel: connect1.out() ),

   //insert here an instance of multiplier with a multiplication factor of 4
   new Multiplier ( inChannel: connect1.in(),
                    outChannel: connect2.out(),
                    factor: 4),
   new Consumer ( inChannel: connect2.in() )
]
```

Output



```
next: 1
next: The output is : 4
4
next: The output is : 16
10
next: The output is : 40
0
Finished
```

Figure 1: **Exercise 2-1** - Output from Run Multiplier program.

Explanation The *Multiplier.groovy* process (see Listing 1) is inserted into the process list between the producer and consumer. The *Producer.groovy* process outputs an integer, that has been provided, to the Multiplier process which then outputs each integer multiplied by a constant factor which is set in the constructor of the Multiplier instance (see line 6 in Listing 3). The *Consumer.groovy* process prints a meaningful output to the console.

2.2 Integer Sets

Code

Listing 4: "ListToStream.groovy"

```
1  while (inList[0] != -1)
2  {
3    // hint: output list elements as single integers
4    for ( i in 0 ..< inList.size)outChannel.write(inList[i])
5      inList = inChannel.read()
6  }
```

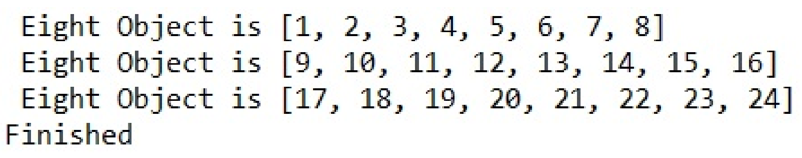
Listing 5: "CreateSetsOfEight.groovy"

```
1  while (v != -1)
2  {
3    for ( i in 0 .. 7 )
4    {
5      // put v into outList and read next input
6      outList[i] = v
7      v = inChannel.read()
8    }
9    println " Eight Object is ${outList}"
10 }
```

Listing 6: "GenerateSetsOfThree.groovy"

```
1  void run()
2  {
3    def threeList = [
4      [1, 2, 3],
5      [4, 5, 6],
6      [7, 8, 9],
7      [10, 11, 12],
8      [13, 14, 15],
9      [16, 17, 18],
10     [19, 20, 21],
11     [22, 23, 24],
12     [-1, -1, -1]]      // terminating list
13   for ( i in 0 ..< threeList.size)outChannel.write(threeList[i])
14   //write the terminating List as per exercise definition
15 }
```

Output



```
 Eight Object is [1, 2, 3, 4, 5, 6, 7, 8]
 Eight Object is [9, 10, 11, 12, 13, 14, 15, 16]
 Eight Object is [17, 18, 19, 20, 21, 22, 23, 24]
Finished
```

Figure 2: **Exercise 2-2** - Output from Run Three to Eight program.

Exercise Questions

What change is required to output objects containing six integers?

Within the *CreateSetsOfEight.groovy* process, change the number of iterations of the for loop. See line 3 of listing 5. The new line should read

Listing 7: "CreateSetsOfEight.groovy - Change required to output objects containing six integers"

```
1  //for (i in 0 .. 7) {
2  for (i in 0 .. 5) {
```

which will now create lists containing 6 integers. This can be improved by changing the number to a variable which is set through the constructor of the process.

How could you parameterise this in the system to output objects that contain any number of integers (e.g. 2, 4, 8, 12)?

The process can be improved by creating a parameter for the size of the output list, bearing in mind the iterations start from zero so the required size should be minus one of the input parameter. This can either be a variable that is set within the constructor of the *CreateSetsOfEight.groovy* process or by user input from the console.

What happens if the number of integers required in the output stream is not a factor of the total number of integers in the input stream (e.g. 5 or 7) ?

Some integers from the input stream will not be outputted to the console as they do not make up a full set of numbers. So the set cannot be filled and therefore the set will not display as the process cannot finish.

Exercise 3

3.1 Reversing GIntegrate

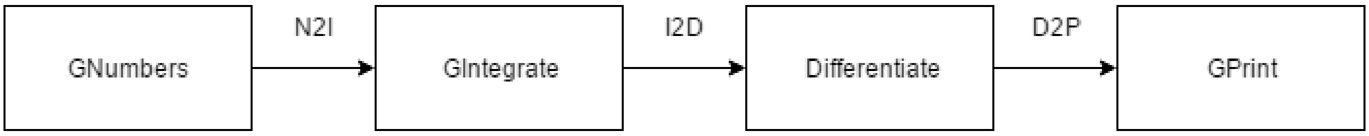


Figure 3: **Exercise 3-1** - Network for process reversing the effect of *GIntergrate.groovy*.

GNumbers.groovy outputs a stream of integers starting at zero and incrementing by one each time. *GIntegrate.groovy* increments the stream by an increasing number each time so the difference between the output is increasing. To negate this effect the output from the network should be equal to the output from the initial GNumbers process.

Minus Process

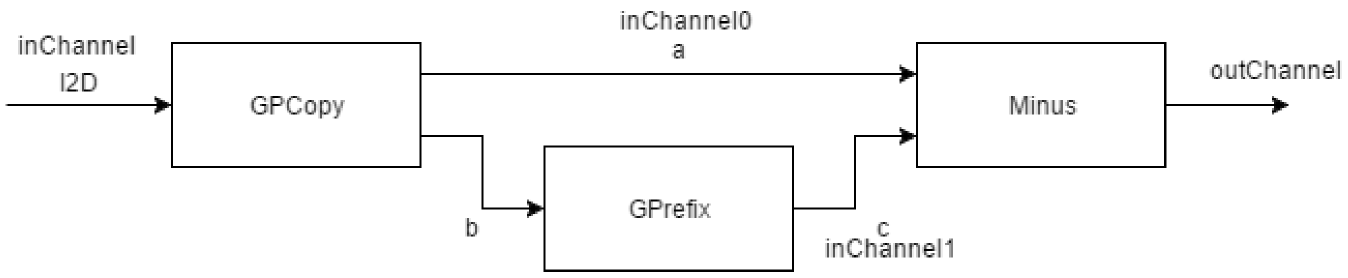


Figure 4: **Exercise 3-1** - Network showing processes for *Differentiate.groovy*.

Explanation The minus process works by copying the output value from *GIntegrate.groovy*, e.g 0, 1, 3, 6. One copy is sent straight to inChannel0 of the *Minus.groovy* process, and the other is sent to *GPrefix.groovy* which outputs the stream with a leading zero into inChannel1 - see Figure 4. The *Minus.groovy* process reads both inputs in parallel and minuses the second from the first resulting in an output stream of incrementing numbers (Figure 5).

Code

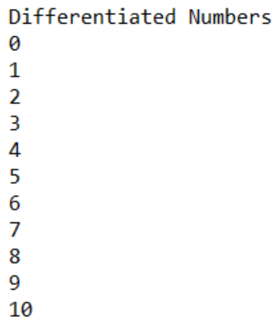
Listing 8: "Minus.groovy"

```
ProcessRead read0 = new ProcessRead ( inChannel0)
ProcessRead read1 = new ProcessRead ( inChannel1)
def parRead2 = new PAR ( [ read0, read1 ] )

while (true) {
    parRead2.run()
    // output one value subtracted from the other
    // be certain you know which way round you are doing the subtraction!!
    outChannel.write(read0.value – read1.value)
}
```

Listing 9: "Differentiate.groovy - see Figure 4 for network of this list"

```
def differentiateList = [ new GPrefix ( prefixValue: 0,
                              inChannel: b.in(),
                              outChannel: c.out() ),
                          new GPCopy ( inChannel: inChannel,
                              outChannel0: a.out(),
                              outChannel1: b.out() ),
                          // insert a constructor for Minus
                          new Minus (inChannel0: a.in(),
                              inChannel1: c.in(),
                              outChannel: outChannel)
                          ]
```

Output



```
Differentiated Numbers
0
1
2
3
4
5
6
7
8
9
10
```

Figure 5: **Exercise 3-1** - Output from the Differentiate System using the Minus Process.

Negator Process

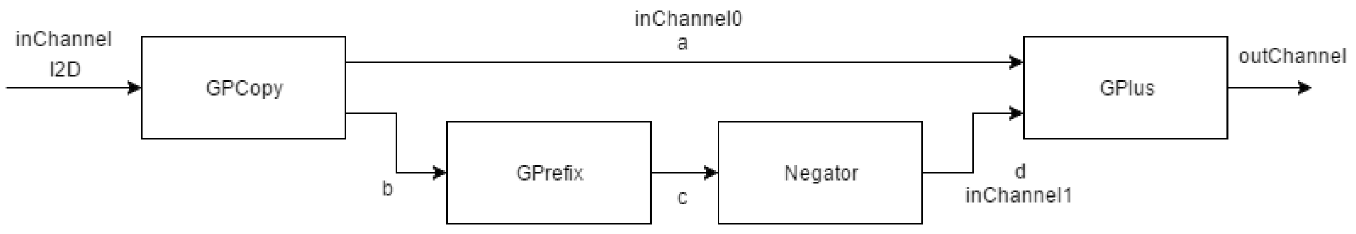


Figure 6: **Exercise 3-1** - Network showing processes for *DifferentiateNeg.groovy* (replacement for Differentiate process within Figure 3)

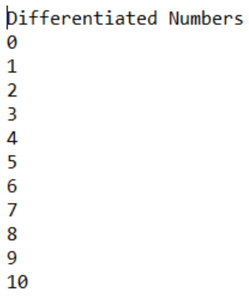
Explanation The negator process works by using the *GPlus.groovy* process which outputs the sum of the two input channels read in parallel. The first input channel is a copy of the original input, whereas the second input channel is a negative version of the input with a leading zero from *GPrefix.groovy*.

Code

Listing 10: "DifferentiateNeg.groovy"

```
def differentiateList = [ new GPrefix ( prefixValue: 0,
                              inChannel: b.in(),
                              outChannel: c.out() ),
                        new GPCopy ( inChannel: inChannel,
                              outChannel0: a.out(),
                              outChannel1: b.out() ),
                        //insert a constructor for Negator
                        new Negator ( inChannel: c.in(), outChannel: d.out()),
                        new GPlus  ( inChannel0: a.in(),
                    inChannel1: d.in(),
                    outChannel: outChannel )
                  ]
```

Output



```
Differentiated Numbers
0
1
2
3
4
5
6
7
8
9
10
```

Figure 7: **Exercise 3-1** - Output from the Differentiate System using the Negator process.

Exercise Questions

Which is the more pleasing solution and why? In this case, even though the Negator solution requires an extra process, it can be argued that this is more pleasing as there is less room for error introduced by the order of the values within the Minus solution. However, a more appropriate solution to negating the effects of GIntegrate would be not to send the values through it in the first place.

3.2 Sequential Copy Process

GSCopy Code

Listing 11: "GSCopy.groovy"

```
void run ()
{
  while (true)
  {
    def i = inChannel.read()
    // output the input value in sequence to each output channel
    outChannel0.write(i)
    outChannel1.write(i)
  }
}
```

Explanation Within the GSCopy the input value is copied by outputting the value to both output channels in sequence not in parallel.

GSPairsA

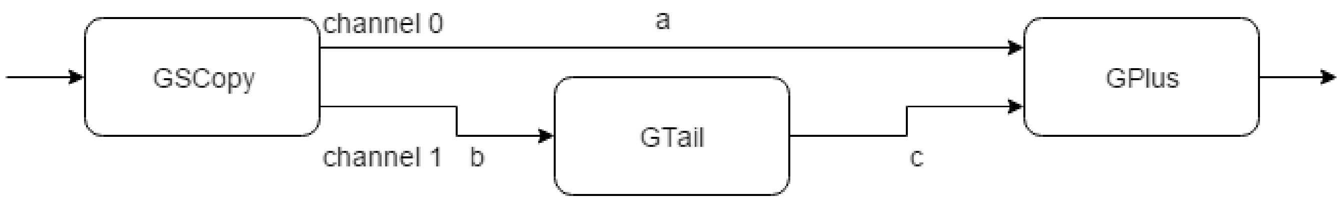
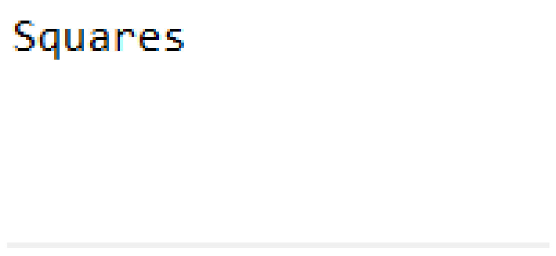


Figure 8: **Exercise 3-2** - Process Network diagram of GSPairsA, as the copy is sequential the output is written first to channel **a** then to channel **b**.

Output



```
Squares
```

Figure 9: **Excercise 3-2** - Output from the Squares system, using the *GSPairsA.groovy* process.

GSPairsB

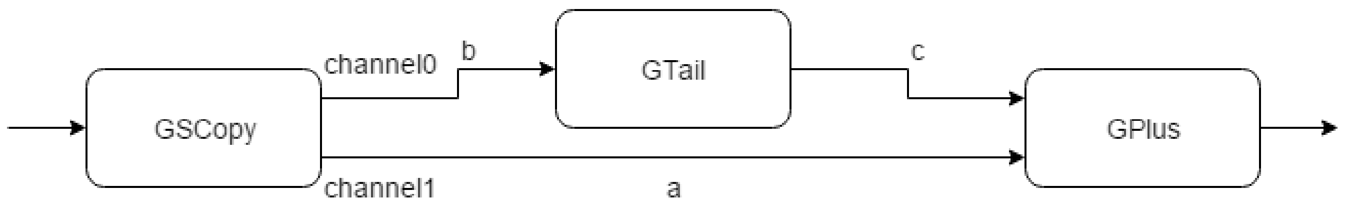
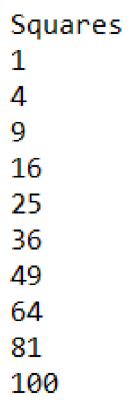


Figure 10: **Exercise 3-2** - Process Network diagram of GSPairsA, as the copy is sequential the output is written first to channel **b** then to channel **a**.

Output



```
Squares
1
4
9
16
25
36
49
64
81
100
```

Figure 11: **Excercise 3-2** - Output from the Squares system, using the *GSPairsB.groovy* process.

Questions

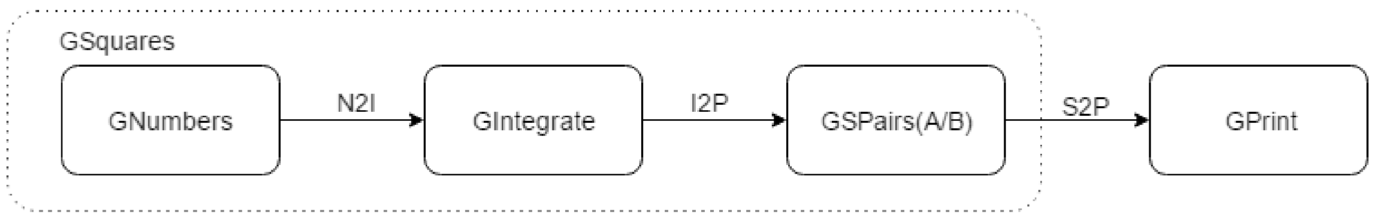


Figure 12: **Exercise 3-2** - Process Network diagram of test system, GSPairs is replaced by GSPairsA and GSPairsB to see the effect.

Determine the effect of the change between GSPairsA and GSPairsB, why does this happen?

In running *GSPairsA.groovy* the output, shown in Figure 9, is blank after the header, whereas in running *GSPairsB.groovy* the output, shown in Figure 11, displays a heading and then a stream of square numbers. The reason for this change is due to the fact *GSCopy.groovy* outputs sequentially and even though the channels are the same, the order in which they are written to is different. See Figures 8 & 10. In the instance using *GSPairsA.groovy* the system deadlocks.*GPlus.groovy* reads both inputs in parallel so cannot process the values until both channels have an input. *GTail.groovy* removes the first input it is given and then outputs the remaining numbers. However *GTail.groovy* cannot receive another input until channel a (the channel between *GSCopy.groovy* and *GPlus.groovy*) is free. The instance using *GSPairsB* does not deadlock as channel b - the channel between *GSCopy.groovy* and *GTail.groovy* - is written to first, so will be able to receive and send the next copied value on the next iteration of the sequential copy.

3.3 GParPrint

Exercise 3 3 (2 marks) Why was it considered easier to build GParPrint as a new process rather than using multiple instances of GPrint to output the table of results?

It is easier to build a parallel printing process rather than using multiple instances of *GPrint* as it allows for printing results from multiple processes at once. It also allows for However as a parallel print needs to wait for every input process to return a value to print, it means that it can only output as fast as the slowest process. Therefore it would only be easier to use if the processes to print output at a regular rate.

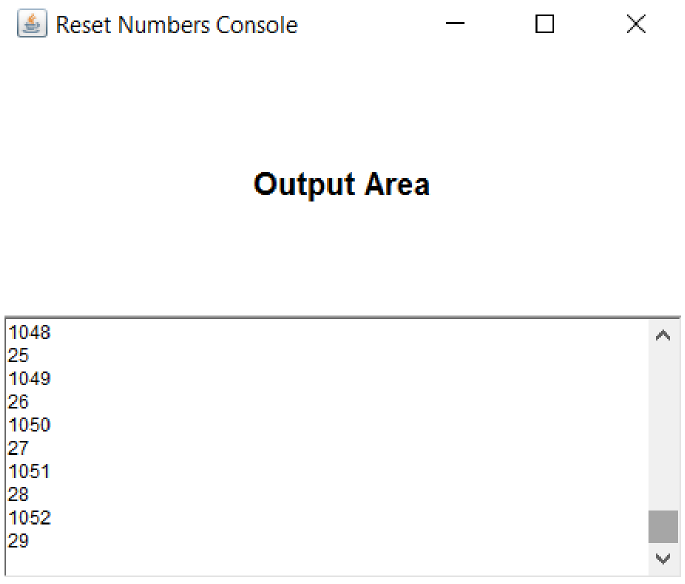
Exercise 4

4.1 ResetPrefix

Listing 12: "Line 25 of ResetPrefix.groovy"

```
    inChannel.read()
```

Output


Reset Numbers Console

Output Area

```
1048
25
1049
26
1050
27
1051
28
1052
29
```

Figure 13: **Exercise 4-1** - Output from the ResetNumbers program when line 25 of *ResetPrefix.groovy* is removed.

Questions

What happens if line 25 of ResetPrefix Listing 4-1 is commented out? Why?

When the read line is removed the output alternates between the incrementing reset value and the original numbers. This is because the original value is not removed from the system if the channel is not read from.

Explore what happens if you try to send several reset values hence, explain what happens and provide a reason for this.

dlock

4.2 ResetSucessor process

Code

Listing 13: "ResetSucessor.groovy"

```
while (true)
{
   // deal with inputs from resetChannel and inChannel
   // use a priSelect
   def index = alt.priSelect();

   if (index == 0)        // reset Channel input
   {
      def resetVal = resetChannel.read()
      inChannel.read()
      outChannel.write(resetVal)
   }
   else                   // outChannel input
   {
      outChannel.write(inChannel.read() +1)
   }
}
```

Listing 14: "ResetNumbers.groovy"

```
def testList = [
   new GPrefix ( prefixValue: initialValue,
      outChannel: a.out(),
      inChannel: c.in() ),
   new GPCopy ( inChannel: a.in(),
      outChannel0: outChannel,
      outChannel1: b.out() ),
   // requires a constructor for ResetSuccessor
   new ResetSuccessor (inChannel: b.in(),
      outChannel: c.out(),
      resetChannel: resetChannel )
]
```

Diagram

Output

Question *Does it overcome the problem identified in Exercise 1? If not, why not?*

Exercise 5

5.1 Varying delay for RunQueue

The accompanying web site contains a script, called RunQueue, in package ChapterExercises/src/c5 to run the queue network. The delays associated with QProducer and QConsumer can be modified. By varying the delay times demonstrate that the system works in the manner expected. Correct operation can be determined by the QConsumer process outputting the messages âĂIJQConsumer has read 1âĂİ to âĂIJQConsumer has read 50âĂİ in sequence. What do you conclude from these experiments? 5.1 Varying the delay times makes no difference to the process output, it works as expected regardless of changing the times. This happens because it uses preconditions to

5.2 Preconditions

Code

Listing 15: "Scale.groovy"

```
while (true)
{
   switch ( scaleAlt.priSelect(preCon) )
   {
      case SUSPEND :
         //  deal with suspend input
         suspend.read()
         factor.write(scaling)
         suspended = true
```

```
            println "Suspended"
            preCon[SUSPEND] = false
            preCon[INJECT] = true
            break
        case INJECT:
            //  deal with inject input
            scaling = injector.read()
            println "Injected scaling is $scaling"
            suspended = false
            timeout = timer.read() + DOUBLE_INTERVAL
            timer.setAlarm(timeout)
            preCon[SUSPEND] = true
            preCon[INJECT] = false
            suspended = false
            break
        case TIMER:
            //  deal with Timer input
            timeout = timer.read() + DOUBLE_INTERVAL
            timer.setAlarm ( timeout )
            scaling = scaling * 2
            println "Normal Timer: new scaling is ${scaling}"
            break
        case INPUT:
            //   deal with Input channel
            def inValue = inChannel.read()
            def result = new ScaledData()
            result.original = inValue
            result.scaled = inValue * scaling
            outChannel.write( result )
            break
      } //end-switch
   } //end-while
```

Questions Reformulate the scaling device so that it uses pre-conditions rather than nested alternatives. Which is the more elegant formulation? Why?

The latter is the more elegant solution because it avoids nested loops.

Exercise 6

6.1 Test Case for Three-To-Eight

Code

Listing 16: "RunThreeToEightTest.groovy"

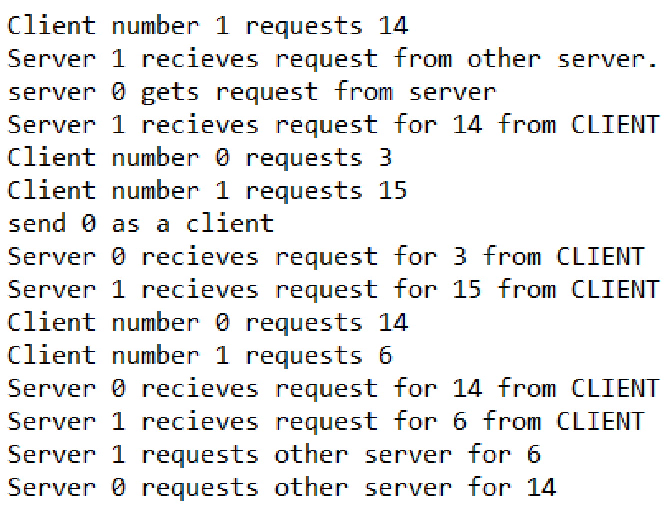
```
class RunThreeToEightTest extends GroovyTestCase
{
    void testThreeToEight()
    {
        One2OneChannel genToStream = Channel.one2one()
        One2OneChannel streamToEight = Channel.one2one()

        def gen = new GenerateSetsOfThree ( outChannel: genToStream.out())
        def list = new ListToStream ( inChannel: genToStream.in(), outChannel: streamToEight.out())
        def eight = new CreateSetsOfEight ( inChannel: streamToEight.in())

        def testRunList = [gen, list, eight]
        new PAR(testRunList).run()

        // test output is correct from eight
        def expectedList = list.inTest
        def actualList = eight.outTest

        println "exp ${expectedList} + act ${actualList}"

        assertTrue(expectedList == actualList)
    }
}
```

Output

Exercise 7

7.1 dead case

Exercise 7 1 (5 marks) By placing print statements in the coding for the Server and Client processes see if you can determine the precise nature of the deadlock in the Client Server system. You will probably find it useful to add a property to the Server process by which you can identify each Server.



```
Client number 1 requests 14
Server 1 recieves request from other server.
server 0 gets request from server
Server 1 recieves request for 14 from CLIENT
Client number 0 requests 3
Client number 1 requests 15
send 0 as a client
Server 0 recieves request for 3 from CLIENT
Server 1 recieves request for 15 from CLIENT
Client number 0 requests 14
Client number 1 requests 6
Server 0 recieves request for 14 from CLIENT
Server 1 recieves request for 6 from CLIENT
Server 1 requests other server for 6
Server 0 requests other server for 14
```

Figure 14: **Excercise 7-1** - Output from the Server Client process

Output As you can see from the output of the program, both servers request values from eachother that causes the deadlock,

Exercise 8

8.1 test case

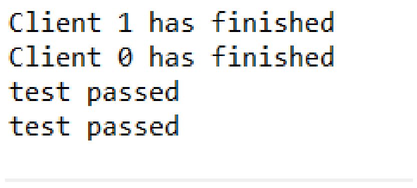
Exercise 8 1 (4 marks) Modify the Client process c07.Client so that it can ensure that the values returned from the Server arrive in the order expected according to their selectList property. It should print a suitable message that the test has been undertaken and whether it passed or failed. You are not to use the GroovyTestCase mechanism because this would require that the CSMux and Server processes would have to terminate, which would require a lot of unnecessary programming.

Code

Listing 17: "Client.groovy"

```
void run()
{
   def iterations = selectList.size
   println "Client $clientNumber has $iterations values in $selectList"

   for ( i in 0 ..< iterations) {
      def key = selectList[i]
      println "Client number $clientNumber requests $key"
      requestChannel.write(key)
      def v = receiveChannel.read()

      // add response from server to actual response list
      actualList << v
   }

   println "Client $clientNumber has finished"

   // multiply each value by ten and add in order from selectList = expected value from server
   for(i in 0 ..< iterations)expectedList << selectList[i]*10

```

```
    // check if actual equals expected
    if (actualList.equals(expectedList))
      println "test passed"
    else
      println "test failed"
  }
```



```
Client 1 has finished
Client 0 has finished
test passed
test passed
```

Figure 15: **Excercise 8-1** - Output from the Server Client test.

Output

Exercise 9

9.1 missed test

Exercise 9 1 (5 marks) Using the suggestion (Section 9.4.4) made earlier in the chapter, construct an additional process for the event handling system that ensures that the number of missed events is correct. The additional process should be added to the network of processes. You may need to modify the EventData class (Section 9.2.4) to facilitate this.

9.2 MultiStream

Exercise 9 2 (5.marks) The accompanying exercise package contains a version of the event handling system, RunMultiStream, which allows the creation of 1 to 9 event streams. By modifying the times associated with each event generation stream and also of the processing system explore the performance of the system. What do you conclude?

9.3 multiplexer

Exercise 9 3 (6 marks) The process EventProcessing has three versions of multiplexer defined within it, two of which are commented out. By choosing each of the options in turn, comment upon the effect that each multiplexer variation has on overall system performance.

Exercise 11

11.1 control

Exercise 11 1 (8 marks) The Control process in the Scaling system currently updates the scaling factor according to an automatic system. Replace this with a user interface that issues the suspend communication, obtains the current scaling factor and then asks the user for the new scaling factor that is then injected into the Scaler. The original and scaled values should also be output to the user interface. Total Marks (60)