Concurrent Programming Practical
3: Hamming Numbers

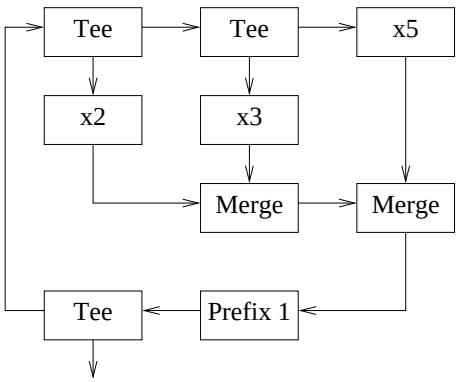
It is recommended that you read the material from the section of the course on *Message Passing* (using Channels) before you attempt this practical.

The aim of the practical is to implement a dataflow network to generate an ordered sequence of *Hamming Numbers*, with no duplicates. The (inductive) definition of the Hamming numbers is as follows:

- 1 is a Hamming number.
- If h is a Hamming number, then so are $2h$, $3h$ and $5h$.

Another way of thinking of the Hamming numbers is that they are those whose only prime factors are 2, 3 and 5.

The illustration below shows a network that solves the problem. If you have read the material suggested, it should be fairly obvious what the various components are expected to do. The component `Merge` receives two ordered streams, and merges them into a single ordered stream, without repetitions.



Your Task

Implement the network.

You may make use of components from the package `io.threadcso.component` if you like (but note that `io.threadcso.component.merge` has a different behaviour from the `Merge` required here). In some cases you will need to implement your own components, especially to answer some of the questions below.

If you implement the network with no buffering on any of the channels, you will find that it deadlocks. Explain precisely how this deadlock arises: you should explain what state each component is in in the deadlocked state. You might need to adapt some of the components in order to understand this behaviour.

Re-implement the network with sufficient buffering to enable it to find the value of the 1000th Hamming number. The declaration

```
val c = OneOneBuf[T](size)
```

defines `c` to be an asynchronous buffered channel, passing data of type `T`, with capacity `size`. Think about which channels need to be buffered, and which can remain unbuffered.

Optional: Modify the components so that all the processes terminate cleanly once the 1000th Hamming number has been output.

Just for fun: Generalize the construction of the network so that it generates the sequence of "Hamming-like" numbers whose factors are given as a list of parameters to your program.

Reporting

Your report should be in the form of a well-commented program, together with brief answers to the above points.

Bernard Sufrin
15th **January, 2016(4.1325)**