

Written Assignment 6

CS 538, Spring 2020

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1 Stepping processes (15)

0. $x \Leftarrow I; x \Rightarrow A; done | y \Leftarrow A; y + 1 \Rightarrow O; done$

$$\begin{aligned} & \xrightarrow{\bar{I}, 42} 42 \Rightarrow A; done | y \Leftarrow A; y + 1 \Rightarrow O; done \\ & \longrightarrow done | 42 + 1 \Rightarrow O; done \\ & \longrightarrow done | 43 \Rightarrow O; done \\ & \xrightarrow{O, 43} done | done \end{aligned}$$

1. $x \Leftarrow I; x + 1 \Rightarrow O; done$

$$\begin{aligned} & \xrightarrow{\bar{I}, 42} 42 + 1 \Rightarrow O; done \\ & \longrightarrow 43 \Rightarrow O; done \\ & \xrightarrow{O, 43} done \end{aligned}$$

2. $x \Leftarrow I; ([x > 12] 100 \Rightarrow O; done) + ([x \leq 12] 5 \Rightarrow O; done)$

$$\begin{aligned} & \xrightarrow{\bar{I}, 42} ([42 > 12] 100 \Rightarrow O; done) \\ & \longrightarrow ([true] 100 \Rightarrow O; done) \\ & \longrightarrow (100 \Rightarrow O; done) \\ & \xrightarrow{O, 100} done \end{aligned}$$

3. $x \Leftarrow I; x - 1 \Rightarrow O; done | x \Leftarrow I; x + 1 \Rightarrow O; done$

$$\begin{aligned} & \xrightarrow{\bar{I}, 42} 42 - 1 \Rightarrow O; done | x \Leftarrow I; x + 1 \Rightarrow O; done \\ & \longrightarrow 41 \Rightarrow O; done | x \Leftarrow I; x + 1 \Rightarrow O; done \\ & \longrightarrow done | x \Leftarrow I; x + 1 \Rightarrow O; done \\ & \longrightarrow done | 41 + 1 \Rightarrow O; done \\ & \longrightarrow done | 42 \Rightarrow O; done \\ & \xrightarrow{O, 42} done | done \end{aligned}$$

4. $x \Leftarrow I; x \Rightarrow A; done|y \Leftarrow A; y + y \Rightarrow O; done$

$$\begin{aligned} & \xrightarrow{\bar{I}, 42} 42 \Rightarrow A; done|y \Leftarrow A; y + y \Rightarrow O; done \\ & \longrightarrow done|42 + 42 \Rightarrow O; done \\ & \longrightarrow done|84 \Rightarrow O; done \\ & \xrightarrow{O, 84} done|done \end{aligned}$$

5. $mk\ A\{x \Leftarrow I; x \Rightarrow A; done|y \Leftarrow A; y + y \Rightarrow O; done\}$

$$\begin{aligned} & \xrightarrow{\bar{I}, 42} mk\ A\{42 \Rightarrow A; done|y \Leftarrow A; y + y \Rightarrow O; done\} \\ & \longrightarrow mk\ A\{done|42 + 42 \Rightarrow O; done\} \\ & \longrightarrow mk\ A\{done|84 \Rightarrow O; done\} \\ & \xrightarrow{O, 84} mk\ A\{done|done\} \end{aligned}$$

2 Writing processes (10)

1. $x \Leftarrow I; x + 1 \Rightarrow A; z \Leftarrow B; z + 3 \Rightarrow O; done|y \Leftarrow A; y + 2 \Rightarrow B; done$

$$\begin{aligned} & \xrightarrow{\bar{I}, 42} 42 + 1 \Rightarrow A; z \Leftarrow B; z + 3 \Rightarrow O; done|y \Leftarrow A; y + 2 \Rightarrow B; done \\ & \longrightarrow 43 \Rightarrow A; z \Leftarrow B; z + 3 \Rightarrow O; done|y \Leftarrow A; y + 2 \Rightarrow B; done \\ & \longrightarrow z \Leftarrow B; z + 3 \Rightarrow O; done|43 + 2 \Rightarrow B; done \\ & \longrightarrow z \Leftarrow B; z + 3 \Rightarrow O; done|45 \Rightarrow B; done \\ & \longrightarrow 45 + 3 \Rightarrow O; done|done \\ & \longrightarrow 48 \Rightarrow O; done|done \\ & \xrightarrow{O, 48} done|done \end{aligned}$$

2. $mk\ A\{x \Leftarrow B; x + 1 \Rightarrow A; done\}|mk\ B\{y \Leftarrow A; y + 2 \Rightarrow B; done\}$

Here the first thread and the second thread are waiting on channel B and channel A respectively. But both of the threads are unable to do useful work because there is a circular wait in progress and hence a deadlock has been established. So, this process cannot make any progress.

3 Recursive processes (5)

1.

$$X \triangleq X|(x \Leftarrow A; x + x \Rightarrow B; done)$$

Main process here is the process variable X

Trace using a Client Process:

$$\begin{aligned}
& \xrightarrow{\bar{I}, 42} 42 \Rightarrow A; 42 \Rightarrow A; \text{done} | (X) \\
& \longrightarrow 42 \Rightarrow A; 42 \Rightarrow A; \text{done} | (X | (x \leftarrow A; x + x \Rightarrow B; \text{done})) \\
& \longrightarrow 42 \Rightarrow A; \text{done} | (X | (42 + 42 \Rightarrow B; \text{done})) \\
& \longrightarrow 42 \Rightarrow A; \text{done} | (X | (84 \Rightarrow B; \text{done})) \\
& \longrightarrow 42 \Rightarrow A; \text{done} | (X | (\text{done})) \\
& \longrightarrow 42 \Rightarrow A; \text{done} | (X | (x \leftarrow A; x + x \Rightarrow B; \text{done}) | (\text{done})) \\
& \longrightarrow \text{done} | (X | (42 + 42 \Rightarrow B; \text{done}) | (\text{done})) \\
& \longrightarrow \text{done} | (X | (84 \Rightarrow B; \text{done}) | (\text{done})) \\
& \longrightarrow \text{done} | (X | \text{done} | \text{done}) \\
& \cdot \\
& \cdot \\
& \cdot
\end{aligned}$$

The main process will continue to listen

2.

$$\begin{aligned}
X &\triangleq (x \leftarrow A; 0 \Rightarrow B; Y; \text{done}) \\
Y &\triangleq (x \leftarrow A; x + x \Rightarrow B; X; \text{done})
\end{aligned}$$

Main process here is the process variable X

Trace using a Client Process:

$$\begin{aligned}
& \xrightarrow{\bar{I}, 42} 42 \Rightarrow A; 42 \Rightarrow A; \text{done} | (X) \\
& \longrightarrow 42 \Rightarrow A; 42 \Rightarrow A; \text{done} | (x \leftarrow A; 0 \Rightarrow B; Y; \text{done}) \\
& \longrightarrow 42 \Rightarrow A; \text{done} | (0 \Rightarrow B; Y; \text{done}) \\
& \longrightarrow 42 \Rightarrow A; \text{done} | (Y; \text{done}) \\
& \longrightarrow 42 \Rightarrow A; \text{done} | ((x \leftarrow A; x + x \Rightarrow B; X; \text{done}) | \text{done}) \\
& \longrightarrow \text{done} | ((42 + 42 \Rightarrow B; X; \text{done}) | \text{done}) \\
& \longrightarrow \text{done} | ((84 \Rightarrow B; X; \text{done}) | \text{done}) \\
& \longrightarrow \text{done} | ((X; \text{done}) | \text{done}) \\
& \longrightarrow \text{done} | ((x \leftarrow A; 0 \Rightarrow B; Y; \text{done}) | \text{done} | \text{done}) \\
& \cdot \\
& \cdot \\
& \cdot
\end{aligned}$$

The main process will continue to listen