CSC 343 Operating Systems, Spring 2020

Dr. Dale E. Parson, Assignment 1, Implementing and testing a first state machine simulation.
This assignment is due via **make turnitin** from the prisonerd2020 directory by **11:59 PM on Wednesday February 19**. There is a 10% penalty for each day it is late, and I will not accept solutions after I go over my solution in class. Documentation comments are worth 10% of the project. Attendance in class on Wednesday February 5 is worth 15% of the project. The remaining 75% are 10 points per bug.

The goal of this assignment is to learn how to write an introductory state machine in this semester's STM language. We will be simulated the Iterated Prisoner's Dilemma, for reference see:
https://en.wikipedia.org/wiki/Prisoner%27s_dilemma

Perform the following steps to get my handout. You will need to test on machine mcgonagall as previously explained (**ssh mcgonagall** from acad). I usually edit in one window on acad and test I another on mcgonagall, so I can run **make graphs** on acad after my program compiles on mcgonagall to generate one or more graphical image files for the project state machine(s).

```
cd  $HOME                 # or start out in your login directory
mkdir  OpSys  # All of this semester's work goes under here, skip if you did it before.
cd  ./OpSys
cp  ~parson/OpSys/prisonerd2020.problem.zip  prisonerd2020.problem.zip
unzip prisonerd2020.problem.zip
cd ./prisonerd2020
make clean test csv
```

Testing fails with the handout directory as follows:

```
NameError: ERROR, following states in machine thread are unreachable from its start state init:
set(['timeInJail', 'terminated', 'awaitOtherAction'])
make: *** [build] Error 1
```

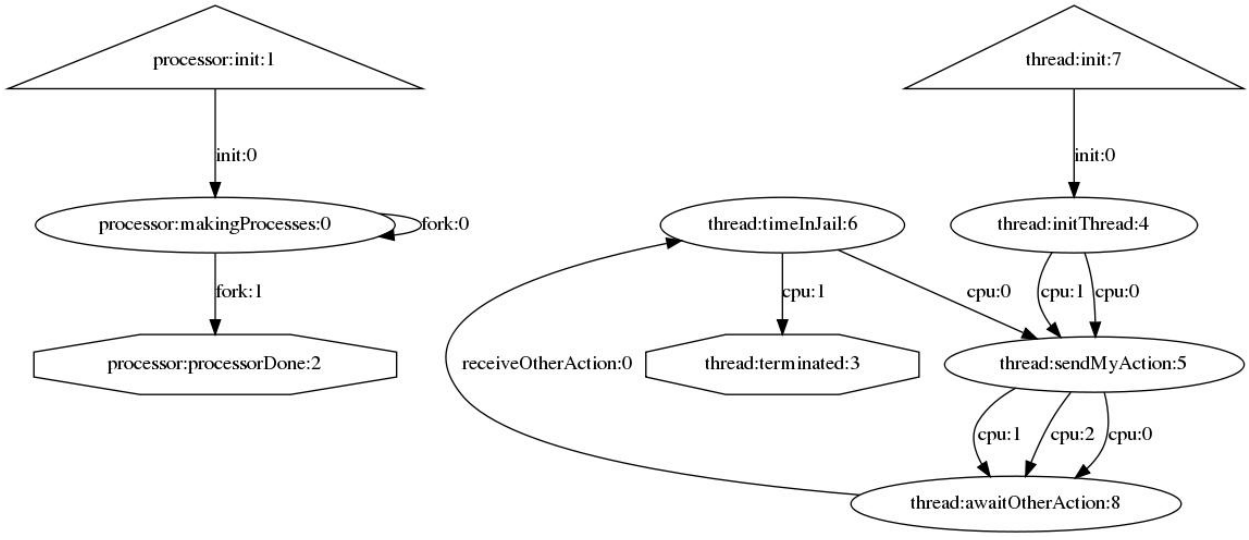
It fails because you need to write transitions that are missing from file **prisonerd2020.stm**. All of your work goes into that file. Look for the STUDENT strings in the file.

We will go over the Iterated Prisoner's Dilemma in class. You can go over the above linked page for more detail. Essentially, in each game of the Iterated Prisoner's Dilemma there are two partners, a process thread ID (tid) of 0, and a tid of 1. At each turn, each player makes a move of "**defect**" or "**cooperate**" without knowing what the other player will do. Then the player computes the penalty for its move in relation to the move made by its partner, according to this scoring table.

My player's move (tid)	Other player's move (othertid)	My penalty for this move
"defect"	"defect"	2
"defect"	"cooperate"	0
"cooperate"	"defect"	3
"cooperate"	"cooperate"	1

See tables **processor.action**, **processor.penalty**, and **processor.processorSampling** in the handout **prisonerd2020.stm** for implementation details. The processor variable is a built-in variable that points to the current processor object. The thread variable points to the current thread object, and the pcb (Process Control Block) variable points to an object shared by the two threads in a single process. This simulation

fork()s 10 processes, and thread 0 spawn()s an additional thread 1 for its partner in its process.



This is the diagram of the final **prisonerd2020.stm** showing all states and transitions. The goal of any player (thread within a process) is to minimize its time spent in the **timeInJail** state. Our simulation records that time for us to analyze. There are four strategies enumerated in **processor.action**, which my handout code places into each thread's **mystrategy** variable. Here are the strategies.

Strategy	Resulting action (how to find action to send to partner)
"defect"	Always send a "defect" message.
"cooperate"	Always send a "cooperate" message.
"halfsy"	Use sample(0,1,"uniform") to get a 0 or 1; send "defect" on a 0 and "cooperate" on a 1. This is a pseudo-random strategy with a 50% probability of defecting and a 50% probability of cooperating on each move.
"reciprocate"	Send "cooperate" on the first move, and on every move thereafter, simply echo the partner's **previous** move. (You don't know what its current move will be.)

The game must be coded to make exactly 100 moves, and then go into the terminated state, using variables **loopCount**, **loopLimit**, and a guard condition on the transition into the terminated state that we will discuss in class.

I have written the **processor** state machine (do not change it), the state declarations and the first three transitions of the **thread** state machine, and some of the variable initializations in that state machine. You will need to create some additional variables, but no new states. Your diagram may match mine above, or you may have four transitions from sendMyAction to awaitOtherAction, depending on how you code your guard conditions for those transitions. Here I summarize the states and transitions, including the ones that I am supplying.

The transition from **init** to **initThread** initializes variables machineID (we don't use it), **pid**, **tid**, and **mystrategy**. It schedules the cpu event that will take it out of initThread in a final action call to cpu(0). Any cpu scheduling that you perform as a transition's final action must be **cpu(0)**, with one exception. The only exception is the cpu(N) call into state **timeInJail**, which must compute a penalty between 0 and 3, inclusive, based on the table at the bottom of the previous page. The N in cpu(N) is that per-move penalty for transiting into **timeInJail**.

You must code 3 or 4 transitions from **sendMyAction** to await **otherAction**, depending on how you code guard conditions for those transitions. Python uses keywords "and" and "or" instead of "&&" and "||" for combining multiple Boolean conditions, if you decide to code guards that way. That is not required. The

up to 4 transitions correspond to the 4 strategies in the above table. Compute a value for variable **SendRecvAction**, based on the appropriate strategy for this thread, and then invoke **SendRecvSync@** (no trailing ";") as the final action. We will discuss macro **SendRecvSync** and its variable **SendRecvAction** in class. **SendRecvSync** sends the value in **SendRecvAction** to the partner, and then waits for the partner to send its own **receiveOtherAction** event. That **receiveOtherAction(action)** event carries the partner's action ("defect" or "cooperate") as its event argument; this event triggers the transition into state **timeInJail**.

On that transition into timeInJail, perform the following statement as the first action.

```
pcb.incomingMessage[tid] = None;
```

Macro **SendRecvSync** uses a combination of the **receiveOtherAction(action)** event and message buffer pcb.incomingMessage[tid] to solve a synchronization problem that we will discuss in class. The above assignment statement clears the buffer after this player has consumed its message in preparation for a later move interaction. **None** is Python's equivalent of the NULL pointer.

The transition into **timeInJail** computes the penalty based on the above information for a call to cpu(penalty), with the thus-generated cpu() event getting the machine out of **timeInJail**. This simulation is profiling the cpu time spent in **timeInJail**.

The transition guard expressions out of **timeInJail** compare variable **loopCount** to **loopLimit**, going to the terminated state when loopCount >= loopLimit.

Note that you MUST increment variable loopCount, and initialize variables needed by the strategies, and update those variables within the appropriate transitions, according to your design for the 4 strategies. Let the 4 strategies guide your creation of additional variables and your decisions for the transitions on which to update variables.

When you are ready, run **make clean test csv** on **mcgonagall** to run tests. The **csv** *make target* generates a comma-separated value file for statistical analysis from a successful test run; **csv** will not run when the **test** part of make fails. Here is what a successful test run looks like.

```
$ make clean test csv
/bin/rm -f *.o *.class .jar core *.exe *.obj *.pyc
/bin/bash -c 'chmod 666 ~parson/tmp/parson_STM*'
chmod: WARNING: can't access /home/KUTZTOWN/parson/tmp/parson_STM*
make: [clean] Error 1 (ignored)
/bin/bash -c '/bin/rm -f *.out *.dif *.pyc junk parsetab.py *.vmlf prisonerd2020_crunch.png'
/bin/bash -c '/bin/rm -f *.dot *.gif *.jpg testmachine.ck junk.* *.tmp *.log prisonerd2020.py'
/bin/bash -c '/bin/rm -f *.crunch ~parson/tmp/parson_STM_*.log parson_STM_*.log Unsafe*.log'
/bin/bash -c '/bin/rm -f rr*.py sjf*.py fcfs*.py plotcrunch.csv *.crunch *_crunch.py *.crunch
*_crunch.csv'
COMPILING prisonerd2020
/bin/bash -c "PYTHONPATH=/home/KUTZTOWN/parson/OpSys:.:.. /opt/csw/bin/python
/home/KUTZTOWN/parson/OpSys/state2codeV12/State2CodeParser.py prisonerd2020.stm
prisonerd2020.dot prisonerd2020.py CSC343Compile CSC343Compile"
INFO: Blocking function spawn is in mid-transition from thread.initThread -> sendMyAction, so its
completion event will not trigger a state change.
COMPILING COMPLETED
SIMULATING (TESTING) prisonerd2020
```

```
/bin/rm -f ~parson/tmp/parson_STM_*.log parson_STM_*.log prisonerd2020.log
/bin/bash -c "PYTHONPATH=/home/KUTZTOWN/parson/OpSys:.:.. STMLOGDIR=~parson/tmp time
/opt/csw/bin/python prisonerd2020.py 2 4 500 12345 2"
MSG cmd line: ['prisonerd2020.py', '2', '4', '500', '12345', '2'], usage USAGE: python THISFILE.py
NUMCONTEXTS NUMFASTIO SIMTIME SEED|None LOGLEVEL
.
Scheduler exiting at time 313 within time limit 500, simulation has finished.

real        9.8
user        9.2
sys         0.4
/bin/bash -c 'chmod 666 ~parson/tmp/parson_STM*'
/bin/bash -c "PYTHONPATH=/home/KUTZTOWN/parson/OpSys:.:.. /opt/csw/bin/python crunchlog.py
prisonerd2020.log"

DIFFing prisonerd2020_crunch.py prisonerd2020_crunch.ref
OK: SUM_timeInJail_thread_1_process_3 at 20.0% tolerance.
OK: SUM_timeInJail_thread_1_process_2 at 20.0% tolerance.
OK: SUM_timeInJail_thread_1_process_1 at 20.0% tolerance.
OK: SUM_timeInJail_thread_1_process_0 at 20.0% tolerance.
OK: SUM_timeInJail_thread_1_process_7 at 20.0% tolerance.
OK: SUM_timeInJail_thread_1_process_6 at 20.0% tolerance.
OK: SUM_timeInJail_thread_1_process_5 at 20.0% tolerance.
OK: SUM_timeInJail_thread_1_process_4 at 20.0% tolerance.
OK: SUM_timeInJail_thread_1_process_9 at 20.0% tolerance.
OK: SUM_timeInJail_thread_1_process_8 at 20.0% tolerance.
OK: SUM_timeInJail_thread_0_process_6 at 20.0% tolerance.
OK: SUM_timeInJail_thread_0_process_7 at 20.0% tolerance.
OK: SUM_timeInJail_thread_0_process_4 at 20.0% tolerance.
OK: SUM_timeInJail_thread_0_process_5 at 20.0% tolerance.
OK: SUM_timeInJail_thread_0_process_2 at 20.0% tolerance.
OK: SUM_timeInJail_thread_0_process_3 at 20.0% tolerance.
OK: SUM_timeInJail_thread_0_process_0 at 20.0% tolerance.
OK: SUM_timeInJail_thread_0_process_1 at 20.0% tolerance.
OK: SUM_timeInJail_thread_0_process_8 at 20.0% tolerance.
OK: SUM_timeInJail_thread_0_process_9 at 20.0% tolerance.

# STUDENT, COMMENT OUT NEXT LINE TO SEE THE LOG FILE.
# bash -c '/bin/rm -f ~parson/tmp/parson_STM_*.log parson_STM_*.log prisonerd2020*.log'
COMPLETED (OK) SIMULATING (TESTING) prisonerd2020
/bin/bash -c "PYTHONPATH=/home/KUTZTOWN/parson/OpSys:.:.. /opt/csw/bin/python plotcrunch.py
diffset prisonerd2020_crunch.py
```

If compilation or testing blows up, you can inspect the log file in **prisonerd2020.log**, searching for error messages and the *defunct* string. Ignore this warning in the log file:

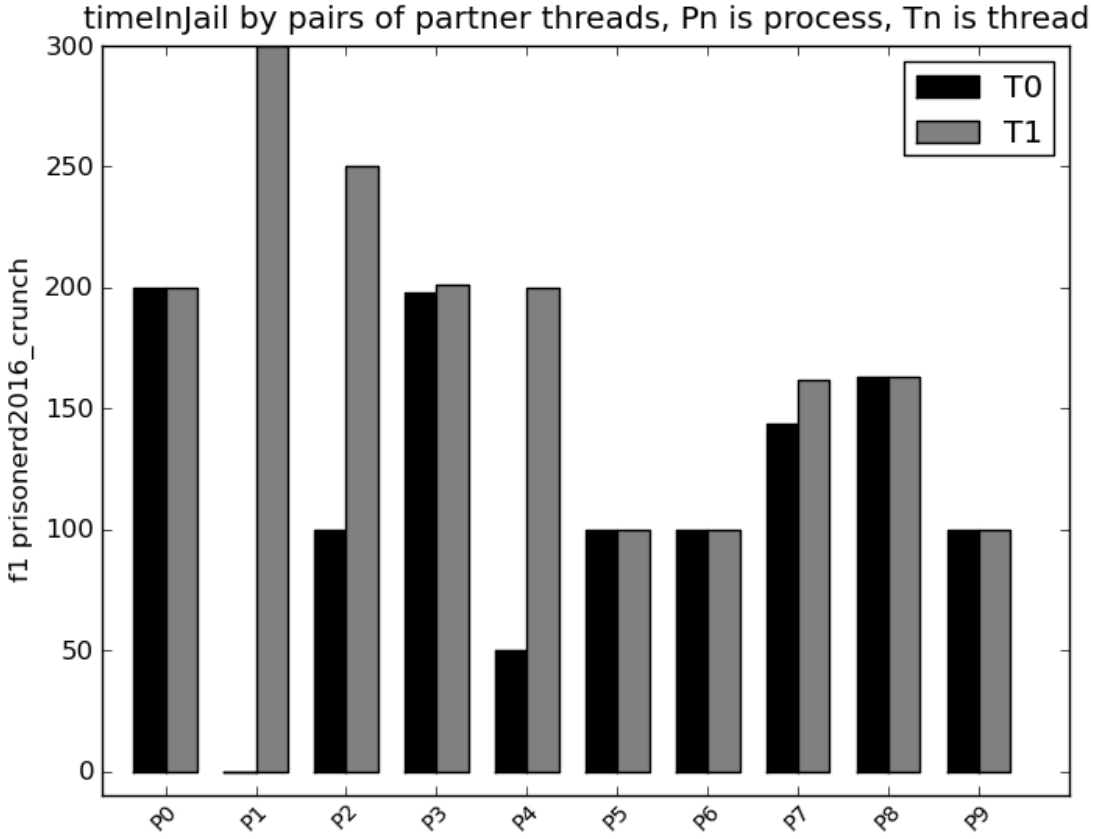
000000000002,MSG,thread 0 process 0,WARNING, signalEvent discards event type receiveOtherAction because model is waiting in queue: waiting on simulation scheduler (simulation sleep) for model: Thread pid 0, tid 0, state sendMyAction, waitingon cpu, __sleepResult__ None, __isdead__False

Macro **SendRecvSync** uses two means to send an action to a partner and await the partner's action, a call

to library function **signalEvent** and message buffer **pcb.incomingMessage[othertid]** as discussed above. When the receiving thread state machine is not in a state that responds to the event sent by **signalEvent**, it logs the above WARNING message. However, since this application checks the **pcb.incomingMessage[tid]** buffer in such cases, we can ignore the warning.

When all goes well with **make clean test csv**, the penalty sums in state **timeInJail** for each thread state machine will match my values in file **prisonerd2020_crunch.ref** to within 20%, and you are ready for the next step.

On machine acad run **make graphs** from within this directory. Even if the file **prisonerd2020_crunch.png** that shows the simulation profile for the test run cannot build because of a failed test, as long as the COMPILE portion of testing has worked, you should be able to view file **prisonerd2020.jpg** to see your state machine. Your **prisonerd2020.jpg** should match mine, except that you may write another transition from **sendMyAction** to **awaitOtherAction**, depending on how you code your guard conditions. Here is my **prisonerd2020_crunch.png**. We will go over its relationship with combinations of the four game strategies in class.



In the above, P0-T0 is **timeInJail** for thread 0 of process 0, followed by **timeInJail** for thread 1 of process 0, which does not have an X label. Then comes **timeInJail** for thread 0 of process 1, and so on. We will discuss the analysis of this graph in class.

When everything works, run **make turnitin** before the project deadline. Make sure to meet any documentation comment requirements stated in the STUDENT comments in the handout code before turning it in, worth 10%. If you later make changes that you want to turn in, just run **make turnitin** again,

which over-writes the previous submission. There is a 10% per-day penalty for late assignments, and I will not accept and assignment after I go over my solution in class. Note we are not using the turnin script in my courses. Also, please run **make clean** whenever you end a work session on this project, since the log files actually reside in ~parson/tmp in order to avoid overloading your file space limits.

See **STM.doc.txt** in the project directory for documentation for the simulation library functions.