CIS 541: Embedded and Cyber Physical Systems

Assignment 4 (Course Project Milestone 1 & 2): Due Wednesday, March 17, 2010

This assignment is the course project Milestone 1 & 2. Make sure you've already formed groups of size 3 or 4 and you are ready to work together.

In these two Milestones, you are to use the Uppaal modeling tool (available from www.uppaal.org) to create formal models of the pacemaker controller.

a. VVI mode. The VVI mode is a simple case of the pacemaker controller. (Refer to Section 3.5 of the pacemaker specification.) A straightforward model can consist of two timed automata: one is the RandomHeart, and the other is the Ventricle. The RandomHeart which can mimic any heart behaviors (e.g., beating just randomly, in a given range.) A RandomHeart in VVI mode will only receive pacing signals to the ventricle and sending signals to the controller when a (spontaneous) heart beat occurs. The Ventricle controller will observe the heart by sensing the heart signal and respond by sending pacing signals to the heart, if the heart fails to beat by itself for a certain amount of time. (For a detailed description of how the pacemaker controller works under VVI mode, refer to Table 6 of the specification and then read related descriptions of each checked item. – Most of them are in Section 5.) Please create an Uppaal model that captures the behavior of a random heart as well as the behavior of the controller. Note that you are not limited to create only in this fashion. Any working models are fine. (For the moment, "Rate Smoothing" is not required.)
b. Simulate your model and make sure it works as you've intended.
c. Specify the properties you think are necessary to establish the correctness result of your design. A baseline rule is that, look at the items in Table 6, each of them should either be a constraint you apply to the model in the design step, or should be a property you verify in the verification step. For each of them, please provide a short reasoning on why the logical formula corresponds to the property listed in the specification. [Hint: To observe how the RandomHeart and the Ventricle controller interact (and specify some properties), it is convenient to create another automaton which captures signals from/to the RandomHeart/Ventricle controller. The observer can be designed on an extend-by-need basis.]
d. Verify the properties in part (c). Ideally, they should all be true, unless you intended a false one.
e. (Extra Credit) Model "Rate Smoothing" for VVI mode. (You can either incorporate this step with (a) or create a separate Uppaal model.)
f. (Extra Credit) Repeat steps (a) to (d) to one of the following modes: VDD, DOO, DDI, or DDD. DDD mode is encouraged. (This can be a separate Uppaal model.)

To submit your work, please write a short description of your design, compress it with the Uppaal models and query files you created, and send them to Professor Lee (lee@cis.upenn.edu) and Shaohui "Vincent" Wang (shaohui@seas.upenn.edu).

NOTE: It is also acceptable to use Matlab or Simulink/Stateflow as your modeling tool. If your group plans to do so, please follow similar steps and turn in zipped models. The model files should be compatible with Matlab version 7 (the version provided on SEAS machines).