CSSE 373 - Formal Methods in Spec. and Design

Alloy Lab 3

Purpose: Understanding operators in Alloy, specifying constraints in Alloy Models, and understanding instances and counter examples in Alloy Analyzer.

Note: Download the workspace folder given to you. Create **[./turnins/HW3.pdf**] for answering problems 1-2.
The files with prefix "E" in the **modules** folder are just examples for you to look at, and those with prefix "P" are the problems that you need to solve. You will need to edit the files with prefix "P".

Before running the lab, make sure you check that you are using SAT4J solver. Go to the **Options** menu -> **Solver** -> **SAT4J**.

Understanding Instances and Evaluator

1. Open *E_Friendship.als* in Alloy Analyzer. Execute the run command. Open the instance and answer the following questions: (**8 points**)

a. Based on the figure, who *Friend$5* considers as its friends?

b. Based on the figure, who considers *Friend$5* as their friend?

c. Go to *Evaluator* and confirm your answer. What expressions did you use to check 1.a and 1.b?
[**Note:** You can use any Alloy expressions including the name given to scalars in the instance. For example, type in *univ* on the evaluator, hit return, and it should display the universal set of the instance. Similarly, type in *Friend$4 in univ*, which should return *true*.]

d. Using evaluator verify that there is at least one way in which Friend$2 is friends with Friend$4 through Friend$5. What expression did you use to check this problem? What did the expression evaluate to?

e. Using evaluator check if there are friends that are friends with every friend (transitively) in the instance. Write down your expression. What did the expression evaluate to?

f. Using evaluator check if all friends are eventually friends with all friends in the given instance. What expression did you use to check this problem? What did the expression evaluate to?

g. Using evaluator create a set of friends that are friends with every friend (transitively) in the instance. Write down your expression. What did the expression evaluate to?

h. Why does Alloy Analyzer show *($degreeSeparation_friend)* in the box for *Friend$5*?

Understanding Bit-Width Used In Alloy

2. Open *P_IntTest.als*. Execute the run command and take a look at the instance. Answer the following questions: (**7 points**)

a. What tuple(s) are there in the "*value*" relation? You can use the evaluator to find out.

b. Go back to the source and modify the constraint "y =< 2" to "y =< 10". Execute the run command and you will see something absolutely crazy happening in the instance produced by Alloy! What weird behavior did you observe?

c. Change the run command as follows: "run show for 1 but 7 Int". Execute the run command. Did it fix the problem? What went wrong before and why the new command fixed it. [**Hint:** Read Section 4.8, Page 137]

d. Open *P_LinearSolver.als*. In the *solve* predicate, specify the following constraints:

    a. x+2y=7
    b. 2x-y = 4.

    Using evaluator find the values for x and y and list them. Do you think Alloy is good for solving integer programming problems? Why or why not? [**Hint:** Read Section 4.8, Page 137]

Creating a Model

3. Assume that all of the faculty and staff in the CSSE department use Facebook, Twitter, or Google+. We want to test the theory of *6 degree of separation* within our department. Present your Alloy model (in *P_Degree_Of_Seperation.*als) that satisfies the following specification: (**35 points**)

Relations in Facebook:

Shawn is friends with Cary, Chandan, and Buffalo.
Chandan is friends with Sriram, Micah, and Steve.

Relations in Twitter:

Sriram is friends with Claude, Amanda, and Lynn.
Amanda is friends with Matt, Michael, and Shawn.

Relations in Google+:

Cary is friends with Michael, Darryl, Buffalo
Darryl is friends with Delvin, David, JP

Friendship for all of the three sites are known to be **irreflexive, symmetric, and transitive**. Note that the same is true between sites. (e.g. Shawn is friends with Darryl because Shawn is friends with Cary in Facebook and Cary is friends with Darryl in Google+, as a result Shawn is friends with Darryl.)

Show that based on the supplied model everybody in the department is friends with everybody else within a 6 degree of separation. Document your model properly explaining how you approached this problem. Also present a snapshot of the Alloy generated instance as a part of your documentation. **Note that your model must preserve facts such as Shawn and Chandan are members in Facebook.** Also note that since there are already more than 6 members in the Friend set, your solution cannot limit the bounds of the Friend set to be 6 as we did in "3-2 Specifying Constraints in Alloy", pp. 7.

Turn-ins: Bundle your workspace folder in the **zip** format **(not rar)** and attach it to the Homework3 submission box on Moodle.