## Lessons Learned in Model Building using Alloy

I created an Alloy model of the tic-tac-toe game.

I got the model working. I checked a couple instances and they showed a perfectly operating model of tic-tac-toe.

I reckoned I was done. Well done. Congratulations.

Just on a whim, I decided to create some assertions.

One thing that must be true in every game of tic-tac-toe is this:

* Players must alternate play. For example, player1 goes first, then player2, then player 1, etc.

I expressed this in an assert. When I checked the assert I was shocked to see “Counterexample found.” Ugh! How can this be? The instances that I had examined showed the game operating perfectly. When I examined the counterexample I realized that once I detected a winner I copied the game board to each succeeding time step but I did nothing about the players on those succeeding time steps. That realization caused me to modify the model:

* There isn’t necessarily a player involved at every time step, i.e., there isn’t necessarily a (Player, Time) pair for every value of Time. There may be some Time values with no Player involved. I made the change. With that change to the model, I needed to change the assert:
  + Players must alternate play ……… for the time steps that involve a player.

Here’s a second thing that must be true in every game of tic-tac-toe:

* Not every game results in a winner; some games end in a tie.

I wrote an assert which expressed this:

* Every game has a winner.

For this I expected a counterexample to be found. You can imagine my surprise when the Alloy Analyzer came back and said, “No counterexample found.” I don’t remember what was the problem in my model. Whatever it was, I found it and fixed it.

Okay, what’s the point? What’s the lesson?

It’s this: You might firmly believe that your model is correct. The instances that you examine confirm your belief. And yet, the model isn’t correct! It has bugs. Lots of bugs. The only way to find those bugs is to write a bunch of asserts that check every part of your model.

Is what I describe also been your experience? What steps do you take to ensure that your model is correct and you’re not deceiving yourself?

*The first principle is that you must not fool yourself — and you are the easiest person to fool.* [Richard Feynman]