Modeling and Simulation (answer three questions)

1. [10 points] Consider a simple airport traffic model for a network of airports. Assume each airport has a single runway, and when an airplane arrives, it must queue to use the runway, land, spend time at the gate for boarding, and then departs again. Furthermore, suppose we also wish to model airport closures, that is, sudden airport shutdowns for some random period of time. Give a complete description of a message passing-based parallel discrete event simulation program for this model. (That is, specify the logical processes, events, propose a synchronization scheme, and be sure to state all assumptions and justify your design.)

2. [10 points] The parallel execution of a discrete event simulation program requires a synchronization algorithm, whereas the parallel execution of a time-stepped simulation, e.g., a cellular automata or continuous simulation, does not. Explain why.

3. [10 points] Consider a parallel discrete event simulation program executing on a parallel computer using Time Warp for synchronization. Assume this is the only program running on the machine, the machine has an unlimited amount of memory and the application program is correct, e.g., does not contain any infinite loops. Define global virtual time (GVT). Is it guaranteed that GVT will advance as the computation proceeds? If yes, prove that GVT is guaranteed to advance. If no, describe a scenario where GVT will not advance. If GVT is guaranteed to advance only if certain condition(s) hold, explain precisely those conditions and prove GVT will advance under the assumption these conditions do hold.

4. [10 points] Consider the dynamical system with two state variables x and y whose behavior over time t is specified by the following equations:

$$x_t = x_{t-1}^2 - y_{t-1}$$

$$y_t = y_{t-1}x_{t-1} - y_{t-1}$$

Is this a linear or non-linear system? What are the equilibrium point(s) for this system? Complete a linear stability analysis of this system by determining the eigenvalues of the Jacobian matrix at each equilibrium point. Based on these calculations, discuss the stability of this system at each equilibrium point. Show all work in deriving your answers.