# Computer Science 483/580
# Concurrent Programming
# Take-home Final Exam
## Due **Friday, May 6, 2011 by 5PM** under the door of my office

There are 6 pages in this exam. Make sure that you are seeing all the pages now.

This exam is **open book and open notes.** You may use a laptop computer to refer to an electronic copy of the textbooks and to your notes. You may also use the Java and Erlang compilers. You ***may*** use your computer to access the network, but **you may not consult with other people** (whether or not they are students) about the exam.

**Honor statement:** I have followed the above instructions in taking this exam.

Signature _____ Date _____

**For this exam you should provide as much *relevant and correct* information as you can in your answers. I'm not looking for brain dumps but neither can many of the questions be answered in a sentence or two. Partial answers will receive partial credit reflecting the degree to which they approach a complete solution and to which they avoid making incorrect statements.**

I expect you to spend about 2 hours on the exam: please take your time to understand what the questions are asking and to give thorough, thoughtful answers.

Your name _____

1. What if the last project had asked you to implement *asynchronous* communication instead of *synchronous* communication? That is, we want to maintain the basic idea of channels to carry messages and the idea of a select() operation that can wait for the first of several channels to be ready to with a value. However, in asynchronous communication send operations don't wait.

1a. In this first part of the question, give a high-level description of a design for such a system by describing the functionality of send(), recv() and select() operations. In particular, I want to see your decisions about what the arguments for each function should be and what should be true when it returns?

1b. Now in this second part, sketch an implementation of send, recv, and select. What data structures are you going to use and how are you going to do synchronization? Assume Java is going to be the implementation language but you can write high-level pseudo-code to express your algorithms. Please do this on a separate page and attach it to the exam that you turn in.

2. We looked at several different server behaviors that are implemented by the OTP framework. One was called a server with "transactional semantics". Given our later discussions about transactions, which of the ACID transactional properties are implemented in the generic server code below. Point out specific features of the code that implement each of the ACID properties or describe why the property is not implemented.

```
%% loop for transactional semantics
loop(Name, Mod, OldState) ->
    receive
      {From, Request} ->
          try Mod:handle(Request, OldState) of
            {Response, NewState} ->
                From ! {Name, ok, Response},
                loop(Name, Mod, NewState)
          catch
            _:Why ->
                log_the_error(Name, Request, Why),
                %% send a message to cause the client to crash
                From ! {Name, crash},
                %% loop with the *original* state
                loop(Name, Mod, OldState)
          end
    end.
```

3. Describe the purpose of the MapReduce primitive and briefly describe how it works.

4. a) In the DSTM paper the CAS instruction has to atomically update an object's *transaction, oldObject* and *newObject* fields when the object is opened for writing. Since on current-day processors the CAS instruction can typically only test and modify one word, how is this three-word atomic update accomplished?

b) (Grad Students) Given our discussion of the DSTM paper and Richard's presentation on Clojure, what is your assessment of STM techniques as a general-purpose mechanism for concurrent programming? One approach you might use to answer this is to consider the strengths and weaknesses and suggest further research needed to resolve the weaknesses.

5. The following code is not safe in the Java memory model.

```
public class S {
    private static T t = null;
    public static T getT() {
        if (t==null) {
            synchronized (S.class) {
                if (t==null) {t = new T();}
            }
        }
        return t;
    }
}
```

5 a) Describe how it violates the Java memory model's requirements and consequently how it can fail.

5 b) suggest at least one way to fix the problem

6. We briefly discussed the virtues and drawbacks of single-threaded GUI designs when talking about Java. The GUI toolkit used in the Lifts assignment in Erlang seems to violate this principle. For example in the cabin.erl file each Cabin is represented by a separate Erlang process and each of those processes calls gs:config() repeatedly to move the image of the respective cabin. Describe a possible design of the Erlang graphics (gs) system that would avoid the problems of race conditions and deadlocks while allowing the kind of usage observed in Cabin.erl. Feel free to draw pictures.