multi-platform, multi-os client/server

- Suppose we send data between clients and servers…

- Architectural issues impact client/server code
  - Little-endian/Big-endian issues
    - 0xabcd is a 32-bit value, which is MSB? How is this stored?
  - How big is an int? 32-bits, 64 bits, …

- Towards raising the level of discussion
  - Worrying about integer byte order is not fun
  - Let's worry about sending objects back-and-forth, not bytes
  - How do we send and receive objects?

Client/Server Communication

- The Java stream hierarchy is a rich source of options
  - Object streams, Data streams, Buffered Readers, ...
  - Often these convert between bytes and characters
    - What's the story with Unicode? (e.g. compared to ASCII)
    - FileStream, BufferedReader, ...,

- We can read and write objects over sockets
  - Advantages compared to lower-level protocols?
  - Disadvantages?

- Issues in understanding and implementing
  - Where do objects "live", are classes different?
  - Subclass/Superclass issues
  - What about connection issues (where, how, knowledge)

Clients and Servers: server side

- Server socket exists on some machine, listens to a "port"
  - A port isn't a physical concept, it's an OS concept
  - The OS manages ports, some services listen at predetermined ports, e.g., mail at port 25
    - User programs use ports above 1024
- Server gets a connection and handles the request, but what about other connection requests?
  - Can't be too busy processing request, or will miss other attempts at connections
  - Spin off handler as a separate program/process
- Server blocks on accepting connections, new jdk1.4 API for java.nio.channels might improve things
  - Why is blocking not ideal?

Networked Games

- What will go over the network?
  - Board?
  - Move?
  - Other?

- Where is the controller?
  - Server?
  - Client?
  - Combination?

- How does the server work for many games?
  - Rules important?

Simple Client/Server code

- The example shows how a client communicates commands to server
  - Deciding how to process a command is simple, but not robust/OO in the current model

- How are client and server similar? Different?
  - Both know about all commands?
  - How do they know this?

Architectural considerations

- What can we do to generalize things, move away from chain of if/else code
  - Create commands corresponding to protocol
  - Execute command obtained by map

- What's in the map? Some commands require state, e.g., more data from server or client
  - Can have a map of string to object, but how to get information into the object?
  - Can map string to object factory, have a per-command factory
  - Factory knows how to create each command

Networked games: ooga to nooga

- Different games make writing general server difficult
  - Turn based games…
  - Multiplayer asynchronous games like Boggle…
  - Noah’s Ark, Samegame, …

- Nooga story at Duke
  - Each summer for the past N summers …
    - Do we have a general, usable architecture?
  - What should we do next?

- What are key issues in developing networked games
  - Don’t worry about robustness or generality

From controller to threads

- Threads are lightweight processes (what's a process?)
  - ➢ Threads are part of a single program, share state of the program (memory, resources, etc.)
  - ➢ Several threads can run "at the same time"
    - What does this mean?
  - ➢ Every Swing/AWT program has at least two threads
    - AWT/event thread
    - Main program thread

- Coordinating threads is complicated
  - ➢ Deadlock, starvation/fairness
  - ➢ Monitors for lock/single thread access

Concurrent Programming

- Typically must have method for ensuring atomic access to objects
  - If different threads can read and write the same object then there is potential for problems
    - ThreadTrouble.java example
    - Consider getting x and y coordinates of a moving object
  - If an object is read-only, there are no issues in concurrent programming
    - String is immutable in Java, other classes can have instance variables be defined as final, cannot change (like const)

- In Java, the keyword synchronized is the locking mechanism used to ensure atomicity
  - Uses per-object monitor (C.A.R. Hoare), processes wait to get the monitor, it's re-entrant

Using synchronized methods

- Methods can be synchronized, an object can be the argument of a synchronized block, a class *cannot* be synchronized
  - Every object has a lock, entering a synchronized method of the object, or using the object in a synchronized block, blocks other threads from using synchronized methods of the object (since the object is locked)
  - If a synchronized method calls another synchronized method on the same object, the lock is maintained (even recursively)
  - Another thread can execute any unsynchronized method of an object O, even if O's lock is held
  - A thread blocks if it tries to execute a synchronized method of an object O if O's lock is held by a different thread

Thread classes in Java

- Classes can extend `java.lang.Thread` or implement `java.lang.Runnable`, (note: Thread implements Runnable)
  - A thread’s run method is executed when the thread is started
  - Typically the run method is “infinite”
    - Executes until some final/done state is reached
    - The run method must call sleep(..) or yield(); if not the thread is selfish and once running may never stop
  - A runnable object is run by constructing a Thread object from the runnable and starting the thread
- Threads have priorities and groups
  - Higher priority threads execute first
  - Thread groups can be a useful organizational tool