Today’s topics

Programming
  Recursion
  Invariants
Digital Intellectual Property Issues

Reading
  Brookshear, Chapter 6
  Richard Stallman, GNU Manifesto, 1993
  Microsoft Corp., "Some Questions Every Business Should Ask About the GNU General Public License (GPL)", 2001

Solving Problems Recursively

- Recursion is an indispensable tool in a programmer’s toolkit
  - Allows many complex problems to be solved simply
  - Elegance and understanding in code often leads to better programs: easier to modify, extend, verify
  - Sometimes recursion isn’t appropriate, when it’s bad it can be very bad—every tool requires knowledge and experience in how to use it

- The basic idea is to get help solving a problem from coworkers (clones) who work and act like you do
  - Ask clone to solve a simpler but similar problem
  - Use clone’s result to put together your answer
- Need both concepts: call on the clone and use the result

Fundamentals of Recursion

- **Base case** (aka exit case)
  - Simple case that can be solved with no further computation
  - Does not make a recursive call
- **Reduction step** (aka Inductive hypothesis)
  - Reduce the problem to another smaller one of the same structure
  - Make a recursive call, with some parameter or other measure that decreases or moves towards the base case
    - Ensure that sequence of calls eventually reaches the base case
    - “Measure” can be tricky, but usually it’s straightforward
- **The Leap of Faith!**
  - If it works for the reduction step is correct and there is proper handling of the base case, the recursion is correct.
- What row are you in?

Classic examples of recursion

- For some reason, computer science uses these examples:
  - Factorial: we can use a loop or recursion, is this an issue?
  - Fibonacci numbers: 1, 1, 2, 3, 5, 8, 13, 21, …
    - $F(n) = F(n-1) + F(n-2)$, why isn’t this enough? What’s needed?
    - Classic example of bad recursion, to compute $F(6)$, the sixth Fibonacci number, we must compute $F(5)$ and $F(4)$. What do we do to compute $F(5)$? Why is this a problem?
  - Towers of Hanoi
    - $N$ disks on one of three pegs, transfer all disks to another peg, never put a disk on a smaller one, only on larger
    - Every solution takes “forever” when $N$, number of disks, is large
  - Reversing strings
    - Append first character after the rest is reversed
Exponentiation

- Computing $x^n$ means multiplying $n$ numbers (or does it?)
  - What's the easiest value of $n$ to compute $x^n$?
  - If you want to multiply only once, what can you ask a clone?

```java
double Power(double x, int n)
// post: returns $x^n$
{
  if (n == 0)
  {
    return 1.0;
  }
  return x * Power(x, n-1);
}
```

- What about an iterative version?

Faster exponentiation

- How many recursive calls are made to compute $2^{1024}$?
  - How many multiplies on each call? Is this better?

```java
double Power(double x, int n)
// post: returns $x^n$
{
  if (n == 0)
  {
    return 1.0;
  }
  double semi = Power(x, n/2);
  if (n % 2 == 0)
  {
    return semi*semi;
  }
  return x * semi * semi;
}
```

- What about an iterative version of this function?

Loop Invariants

- Want to reason about the correctness of a proposed iterative solution
- Loop invariants provide a means to effectively about the correctness of code

```java
while !done do
{
  // what is true at every step
  // Update/iterate
  // maintain invariant
}
```

Bean Can game

- Can contains $N$ black beans and $M$ white beans initially
- Emptied according the following repeated process
  - Select two beans from the can
  - If the beans are:
    - *same color*: put a black bean back in the can
    - *different colors*: put a white bean back in the can
  - Player who chooses the color of the remaining bean wins the game
- Analyze the link between the initial state and the final state
- Identify a property that is preserved as beans are removed from the can
  - *Invariant* that characterizes the removal process
What is digital?

- What’s the difference between
  - Rolex and Timex?
  - VCR tape and DVD?

- How is ripping to a mp3 different from recording to a tape?
  - Reproduction: immediate and future
  - Distribution
  - Modification

- Why do digital media present new challenges from analog media?
  - Is copyright infringement new?

Copyright

- US Constitution (Article I, Section 8, Clause 8): “To promote the Progress of Science and useful Arts”

- What can you copyright?
  - Fixed, tangible medium of expression with a modicum of originality

- How do you copyright?
  - Don’t need anything. Registration necessary for copyright infringement suits
  - Authors given limited monopoly so they will disclose to public
  - Concessions
    1. Fair use
    2. First sale
    3. Limited Time

- Evolving Bargain: Copyright holder may profit from works and public has access and can build upon them
- What would happen if information could only be shared if the owner provided permission?

Fair use

- Use copyrighted works without permission if the use does not unduly interfere with the copyright owner’s market for a work
- Include personal, noncommercial uses
- 4 prong test
  1. Purpose and character of use (commercial vs. non-profit or educational)
  2. Nature of copyrighted work
  3. Amount and substantiality of the portion used
  4. Effect of the copying upon market
- Example: using a VCR to time-shift a broadcast program
- Reverse engineering
  - OK when extracting unprotected elements
  - Connectix Virtual PlayStation

Digital rights management

- Idea: copying is hard to control, so make the copying process itself difficult
  - Restrict the use of digital files in order to protect interest of copyright holders
  - Control file access
  - Implemented in operating system, program software, or in the actual hardware of a device

- Digital watermarking
  - Make information so that unauthorized copying can be detected

- Serial Copy Management System (Audio Home Recording Act 92)
- Dystopian and utopian results?
- Privacy issues?
Important papers

- National Information Infrastructure White Paper 1995
  1. Copyright owners given exclusive rights over “transmission” of information not just copying
  2. Eliminate first-sale doctrine for digital works
  3. Criminalize tampering with copyright protection or identification mechanisms
     > Controversial and bills to implement recommendations were not passed, until...
- Digital Millenium Copyright Act 1998
  - Encourages use of technological protections to facilitate a pay-per-view/use system
  - Copyright used to regulate multiplication and distribution of works but how about consumption?
  - Civil and criminal penalties for circumventing copyright protection systems

Copyrights

- Copyright Term Extension Act 1998
  - Free Mickey Mouse! (challenged in Supreme Court 2003)
  - Retroactive copyright extension of 20 years
  - Breyer: “effect ... is to make the copyright term not limited, but virtually perpetual”
    - Over the last 40 years, Congress has lengthened copyright durations 11 times
    - Copyright term length
      - 95 years for corporations
      - 70 years after death for individuals
- Other forms of exclusive rights in information
  - Patents: inventions that others cannot use
  - Trademark: differentiates between different sources of products
  - Trade secret: pseudo-property right to penalize those who disclose information to unauthorized persons

Questions

- Is copyright infringement stealing?
- What are the differences between writing code and writing books in terms of licensing?
- Discuss the legality of peer-to-peer sharing with respect to the four prongs of determining fair use
- Eben Moglen:
  > If you could feed everyone by pressing a button to create lambchops (for free), is there a moral reason to have starving people?
  > If everything has zero marginal cost and can be given to everyone everywhere why is it ever moral to exclude anyone from anything?

Consequences

- Scientific research
  - Secure Digital Music Initiative & Prof. Edward Felton
  - Adobe & Dmitry Skylarov
- Fair Use
  - Copy-protected CDs
  - DeCSS and DVD Copy Plus
- Innovation and competition
  - Sony vs. Connectix and “Mod Chip” makers
  - Apple & Other World Computing
**Patents**

- **Why patents are powerful?**
  - Right to exclude others from “practicing the invention”
- **Currently operating under Patent Act of 1975**
  - 20 year term
- **Patent and Trademark Office looks at 4 criteria**
  1. Is proposed invention patentable?
  2. Utility
  3. Novelty
  4. Non-obviousness
- **Software patents**
  - Only recently have patents been granted for software or business methods
  - Controversial patent: Amazon.com’s One-Click

**Types of software**

- **Software Licenses**
  - Public domain
  - Free
  - Open Source
  - Copylefted
  - Semi-free
  - Commercial
- **Proprietary (closed) software**
  - Freeware
  - Shareware
  - Adware
  - Spyware
- **Commercial**
  - Academic licenses

**Open source**

- **Commercial software license schemes**
  - Microsoft’s Embrace and Extend
  - What’s a EULA?
- **Rights**
  - Make copies of the program and distribute them
  - Access to the software’s source code
  - Make improvements to the program
- **Results**
  - All contributors at same relative level
  - Lots of competition in distribution or support
  - Why does it work?
- **Free Software Foundation** formed in 1984
  - GNU General Public License (Copyleft)
  - Seminal work produced (emacs, gnu compiler)
  - Spawned different licenses like the [Open Source Definition](#)

**Sources of material**

- **Organizations**
  - The Electronic Frontier Foundation
  - Center for Democracy and Technology
- **Media and discussion**
  - Wired Magazine
  - Slashdot
- **Databases of information and laws**
  - Lexis/Nexis
  - Thomas
- **Social issues in Computer Science**
  - Computer Professionals for Social Responsibility