Today’s topics

Programming
Recursion
Copyrights, patents, and digital media

Reading
Great Ideas, p. 180-186
BrooksShear, Section 5.5 6.3
Online IP readings

Upcoming
Complexity
Security

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?

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?

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?

Recursive example 1

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

Return value:

Recursive example 2

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

Return value:
Recursive example 3

String mystery(int n)
{
    if (n < 2) {
        return "" + n;
    } else {
        return mystery(n / 2) + (n % 2);
    }
}

Return value:

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

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
- 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
  - Why is YouTube not the subject of copyright infringement suits?

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**
  - Is proposed invention patentable?
  - Utility
  - Novelty
  - Non-obviousness

- **Software patents**
  - Only recently have patents been granted for software or business methods
  - Controversial patent: Amazon.com’s One-Click