Today’s topics

Programming
  Recursion
Copyrights, patents, and digital media

Reading
  Great Ideas, p. 180-186
  Brooksheer, 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?

```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?

Recursive example 1

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

x: 

n: 

Return value: 

Recursive example 2

```java
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;
}
```

x: 

n: 

Return value:
Recursive example 3

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

Return value:

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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

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Important papers

- **National Information Infrastructure White Paper 1995**
  - Copyright owners given exclusive rights over “transmission” of information not just copying
  - Eliminate first-sale doctrine for digital works
  - Criminalize tampering with copyright protection or identification mechanisms
    - Controversial and bills to implement recommendations were not passed, until...
- **World Intellectual Property Organization Treaty 1996**
- **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?

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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