Twelve Life Lessons from Software Engineering

1. Design
2. Testing
3. Reuse

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"Software Engineering"

- Software DIY
  - installing shelves at home

- Software Engineering
  - building a bridge or an airplane

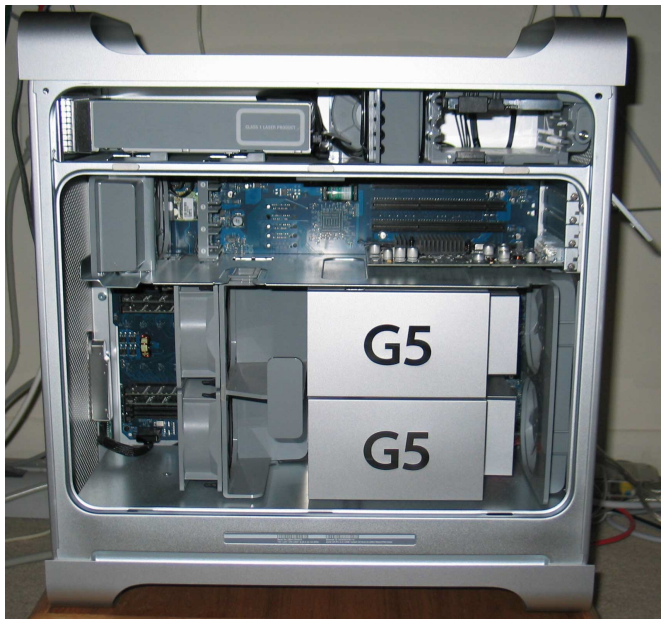
- Projects involving many people need management

My Life as a Programmer

- 1981 (High School): BASIC, 8-bit assembler
- 1985 (College internship): C on a VT-100
- 1988 (Job): APL on a GUI
- 1990 (Grad school): C on a GUI (NeXT)
- 1992 (Grad school): MATLAB
  Unix, Make
  Tcl/Tk
- 1997 (Post-doc): C++ modules, libraries
  Autoconf, RCS
- 2001 (Faculty): MATLAB again
- 2013 (Faculty): Python, Git

1. Writing Code is Writing

- Software is expressing an idea
- There are many ways to do the same thing
  - differences are "second order"
- Aesthetic differences
  - know when you're setting traps
  - minimal commenting



2. Think About the Future

- "DIY" is all about quick hacks
  - something you need for now
  - usually discarded tomorrow
  - but not always
- Many tools have grown far beyond original vision
  - you never know when this will happen
- Worth anticipating
  - even if you are the only user

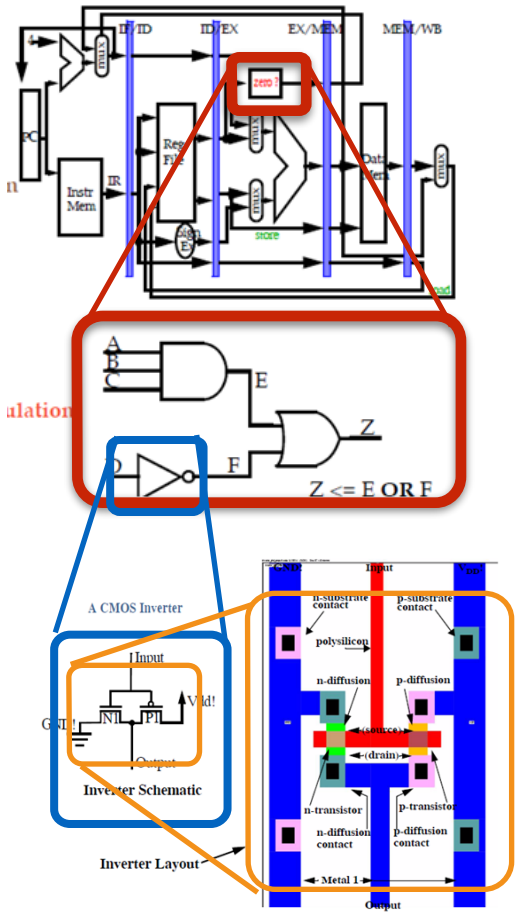
```
function [B,A,T,BW,FC] = bpfiltbank(SR,
% [B,A,T,BW,FC] = bpfiltbank(SR,FMIN,BPO
%       Returns matrices B and A where e
%       definitions for an IIR constant-
%       Their center frequencies range l
%       FMIN with BPO bands per octave i
%       is designed by iirbpfilt.m to ha
%       and an order 2*N.   If TYPE is p
%       filters.  If TYPE is 2, use Slan
%       the 'twoptwoz' filters, else use
%       TYPE=4 is modified Slaney/Patter
%       T is a vector of 'group delay' i
%       BW is a vector of bandwidths of
%       FC is a vector of the actual cen
%       VERB=1 for messages
% dpwe 1994jun21.  Uses iirbpfilt.m

if nargin < 7; TYPE=0; end
if nargin < 8; VERBOSE=0; end

FMAX = FMIN*exp(log(2)*BANDS/BPO);

if (FMIN <= 0) %( || FMAX <= FMIN)
  error('bpfiltbank: must be 0 < FMIN <
```

3. What Can Go Wrong

- We don't know how to solve the problem
- Program is too slow
- Program doesn't apply

- Program has bugs
  - programs are complicated machines
  - sometimes we get in too deep
  - we layer complexity until it fails

4. Modularity



- Decomposing a problem is the genius of engineering
  - Software > Language > OS > Machine Code > Microcode > VLSI > Transistors > Physics
- Decomposing a problem can make the problem disappear
  - threshold of triviality
- Modules help shape your thinking
- Modules offer re-use
- Top-down code composition
  - http://software-carpentry.org/4_0/invperc/assembly.html

5. Interfaces and Data Structures

- Program design has several parts
  - modules
  - data structures
  - interfaces / APIs
- The right representation can make all the difference
  - frames the function of the modules
- Opportunity to increase generality, future applications
- Opens door to existing modules...

6. Use Libraries / Tools

- We are not working in a vacuum
  - there are (probably) other people facing similar problems
  - some of them have made huge investments in tools
  - well-used tools/components are debugged
- Using a library involves a learning curve
  - it could be faster to write it yourself...
  - ... but it might still be better to use a tool
- A judgement call

7. Create Libraries / Tools

- Be on the lookout for recurrent idioms
- If you don't find a library, it's an opportunity
  - to help the community (fame and glory)
  - to increase your future productivity
- Same issues as any sharing of code
  - big investment
  - but: code review, beta testers
- Design becomes important
  - but design is always good

8. Publish Your Code

- **What is needed for a stand-alone presentation of this code?**
  - minimal documentation
  - sometimes have a target in mind
  - but worthwhile even without
  - your future self as the audience
- **E.g. Matlab "publish"**
  - combination of narrative & execution
  - examples of execution
  - (also, an implicit test case)

9. Version Control

- If other people are using your code, you can't just change it
  - edits may introduce bugs
  - users may rely on parts you consider unimportant
- Keep backups
- Make it possible for people to quickly identify which version they're using
- Maintain changelogs

10. Include Explicit Tests

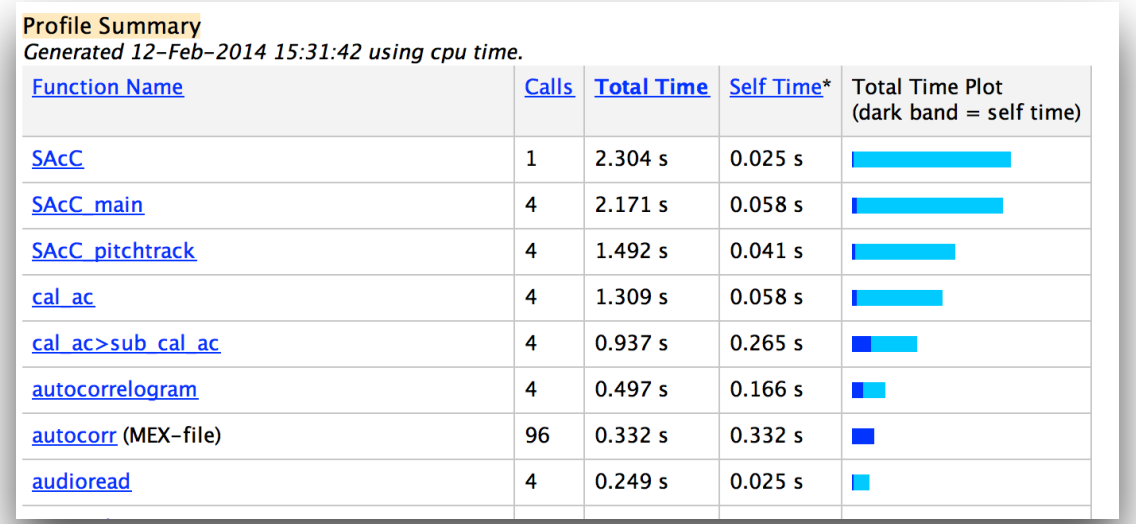
- Often want to go back and tweak code
  - danger! you think you know what's going on
  - "no need to check this..."
- Automated tests
  - in Make file
  - as part of release process
- Just the obvious cases
- http://software-carpentry.org/4_0/test/index.html

10b. Will bugs be observable?

- **Beware of cases where you don't know what to expect**
  - you can't tell if it's doing what you think it was doing

11. Optimization

- One "second-order aspect" is execution speed
  - factors governing speed are frequently mysterious: cache size, compiler optimizations, parallelism
- Execution time is frequently dominated by one or two pieces - the "long pole"
  - profiling to identify + prioritize
- There's usually low-hanging fruit



Profile Summary
Generated 12-Feb-2014 15:31:42 using cpu time.

Function Name	Calls	Total Time	Self Time*	Total Time Plot (dark band = self time)
SAcC	1	2.304 s	0.025 s	
SAcC_main	4	2.171 s	0.058 s	
SAcC_pitchtrack	4	1.492 s	0.041 s	
cal_ac	4	1.309 s	0.058 s	
cal_ac>sub_cal_ac	4	0.937 s	0.265 s	
autocorrelogram	4	0.497 s	0.166 s	
autocorr (MEX-file)	96	0.332 s	0.332 s	
audioread	4	0.249 s	0.025 s	

12. Diminishing Returns

- **Some people love programming**
  - your own private universe - "castles in the sky"
- **Be critical & aware**
  - the balance between
    programming for the future
    and getting the job done
  - you can always fix it later

Summary

- Programming is serious
  - it can take much, much longer than necessary
  - getting hit by bugs is better than not noticing them
- Try to emulate a professional
  - even if you never plan to program professionally
- Learn by doing
  - i.e., the hard way

SAcC

- 2006: Student A re-implements a C-based system in Matlab
- 2010: Student B re-uses code to develop a new feature
- 2012: Feature is incorporated into DARPA program system
  - Industrial research lab expects consistent releases
  - Pressure to improve performance

SAcC

- Source release
- Version tracking
- Automated releases
- Automated tests
- Compiled target
- Python port