CSC 2700: Scientific Computing

Collaboration management, Programming best practices

Dr Frank Löffler

Center for Computation and Technology
Louisiana State University, Baton Rouge, LA

Feb 20 2014

Overview

Overview

Software development, or

- Application Development
- Software Design
- Software Engineering
- Software Application Development
- Enterprise Application Development
- Platform Development

... development of a software product in a planned and structured process.

Overview

Software development involves some combination of stages:

- Market research
- Gathering requirements for the proposed business solution
- Analyzing the problem
- Devising a plan or design for the software-based solution
- Implementation (coding) of the software
- Testing the software
- Deployment
- Maintenance and bug fixing

Collection of stages: software development life-cycle (SDLC).

- Very different methodologies to combine stages exist.
- Choice of methodology should be project-dependent.

Software development in Science

Software development involves some combination of stages:

- Market research
- Gathering requirements for the proposed business solution
- Analyzing the problem
- Devising a plan or design for the software-based solution
- Implementation (coding) of the software
- Testing the software
- Deployment
- Maintenance and bug fixing

Collection of stages: software development life-cycle (SDLC).

- Very different methodologies to combine stages exist.
- Choice of methodology should be project-dependent.

Project Environment / Community

Before starting implementation: create “project environment”:

- Communication channels
- Version control system
- Bug tracker and tasks list
- Documentation format
- Testing tools
- Package management

Communication channels

Communication channels

Dependent on team distribution, consider possibilities like:

- In-person meetings
- Conference phone calls
- Email, especially dedicated mailing lists
- Instant messaging (e.g. IRC)
- VoIP/Video-conferences (e.g. Skype/Google Hangouts/BigBlueButton)

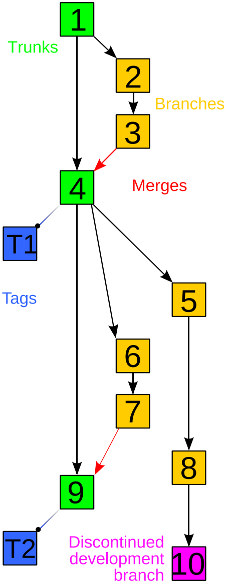
Version control systems

Version control systems

Also known as

- Revision control
- Source control
- Software configuration management

Definition: Management of changes to documents, programs, and other information stored as computer files



Issue tracker

Issue tracker

- Synonyms: trouble ticket system, support ticket or incident ticket system
- More restricted: bug tracking system, bug tracker
- Database of "tickets", describing issues/incidents/bugs

Workflow

1. User notices bug/issue/problem
2. (User tries to create small test case, presenting the problem)
3. User creates/opens ticket in issue tracker
4. Developer reproduces problem
5. Developer fixes problem
6. Developer closes ticket, notifying User

Issue tracker

Tickets/Issues can have attached

- Type (e.g. defect/enhancement)
- Priority (e.g. minor, major, critical, blocker)
- Project component
- Target project milestone
- Version of project component
- List of people CC'ed on changes of ticket
- Owner
- Files (e.g. patches)

Benefits of issue trackers over, e.g. direct developer contact

- Issues are recorded in database, cannot be forgotten
- Users can look-up if specific problem was already reported
- Users can automatically get change notifications

Issue tracker

- A large number of stand-alone issue tracker implementations exist
  - Trac
  - Bugzilla
  - GNATS
- Open-source hosting sites usually automatically provide issue tracking systems, e.g.
  - sourceforge
  - savannah
  - seul
  - github
  - google code

Documentation format

Documentation format

Depending on need, various formats possible

- Plain text
- Man pages / Help system documents
- Application-internal
- Print-oriented, e.g. LaTeX, word processor
- Wiki
- Website as in plain HTML and typically in RCS

Summary

Summary

User- and development-friendly project environment provides:

- Information about project: e.g. website
- Communication channels for developers
- Infrastructure for shared code development
  - Project standards
  - Revision control system
- Communication channels for users, especially
  - Channel for problems/issues, directed at developers
  - Users-for-users channel

Best Coding Practices

or

How not to annoy your collaborators

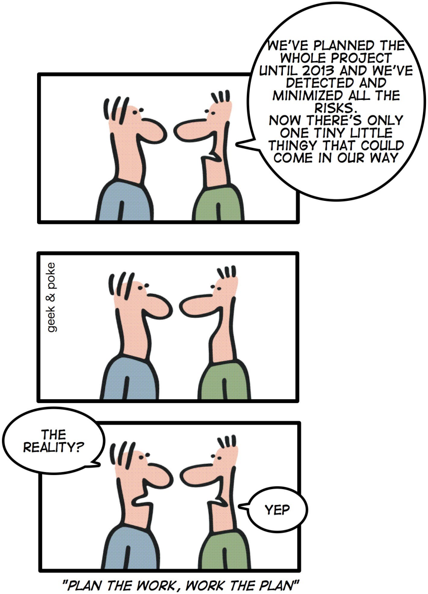
Overview

Best Coding Practices - Don't just do it... do it right!

- Project planning
  - First of all: have a plan!
- Programming styles and conventions
  - Improve readability (to others and yourself)
  - Reduce the probability of (you) introducing errors
  - Make contributions by others more likely

Project Planning

Some day on Geek & Poke



http://geekandpoke.typepad.com/

General Planning / Designing

Plan ahead!

- Define goals
- Define sub-goals
- Define road-map
- Bad plan often is better than having none
- The complete team must understand plan before start
- Do not deviate without reason

Design pitfalls

- Over-designing: 'Don't bite off more than you can chew'
- Two generally good principles
  - "Keep it Simple, Stupid!" - KISS
  - Utilize information hiding

KISS

KISS is acronym for

- Keep it simple, Stupid!
- Keep it short and simple

Key points:

- Simplicity should be a key goal in design
- Unnecessary complexity should be avoided

Related concepts:

- Occam's razor (We should tend towards simpler theories)
- Einstein: *"Everything should be made as simple as possible, but no simpler."*
- Antoine de Saint Exupéry: *"It seems that perfection is reached not when there is nothing left to add, but when there is nothing left to take away."*

Code review

Code review / Peer review:

- Look at other peoples work. Learn from it.
- Solutions for problems often available - use them.
- Let others see your code and learn from their knowledge.
- Sometimes: program together (walk-through, pair programming)

Testing

Testing

- Should not be an afterthought
- Integral part of software development
- Needs to be planned, and done proactively
- Developed while the application is being designed and coded

Testing

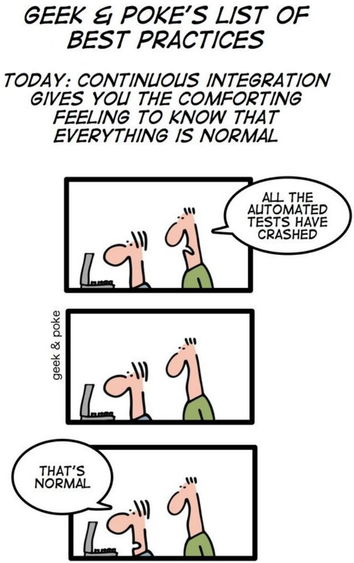
Functional testing

- Verify specific action or function of code
- Usually found in code requirements documentation
- “Can the user do this”

Non-functional testing

- Not related to specific action or function, e.g.
  - Scalability
  - Testability
  - Maintainability
  - Usability
  - Performance
  - Security

Today on Geek & Poke



http://geekandpoke.typepad.com/

Source specific coding styles
Identifier naming

Naming conventions

Reasons:

- to reduce the effort needed to read and understand source code
- to enhance source code appearance
  (for example, by disallowing overly long names or abbreviations)
- to enhance clarity in cases of potential ambiguity
- to help avoid "naming collisions" that might occur when the work product of different organizations is combined

Identifier length

Considerations:

- shorter identifiers may be preferred because they are easier to type
- extremely short identifiers are very difficult to uniquely distinguish using automated search and replace tools
- longer identifiers may be preferred because short identifiers cannot encode enough information or appear too cryptic
- longer identifiers may be disfavored because of visual clutter

Identifier length

Programmers generally tended to use short identifiers, in part because of

- programming languages with length limitations
- early linkers which required variable names to be restricted to 6 characters to save memory
- early source code editors lacking auto-complete
- early low-resolution monitors with limited line length (e.g. only 80 characters)
- much of computer science originating from mathematics, where variable names are often only a single letter

Identifier length example

Compare

```
get a b c

if a < 24 and b < 60 and c < 60
  return true
else
  return false
```

to

```
get hours minutes seconds

if hours < 24 and minutes < 60 and seconds < 60
  return true
else
  return false
```

Naming Conventions

A set of rules for choosing identifiers

- Hungarian Notation
  - embed information (e.g. type) into name
  - lower case mnemonics
  - examples: `sName`, `strName`, `iMax`, `intMax`, `i_max`
  - popular primarily in Microsoft environments
- Underscore style
  - underscore "_" between compound words
  - might be confused with minus sign
  - underscore inconvenient on some keyboard layouts
- CamelCase
  - compound words, joined without spaces, capitalized words
  - uses less characters than underscore notation
  - inappropriate for case-insensitive languages

Source specific coding styles

Source code formatting

Source code formatting

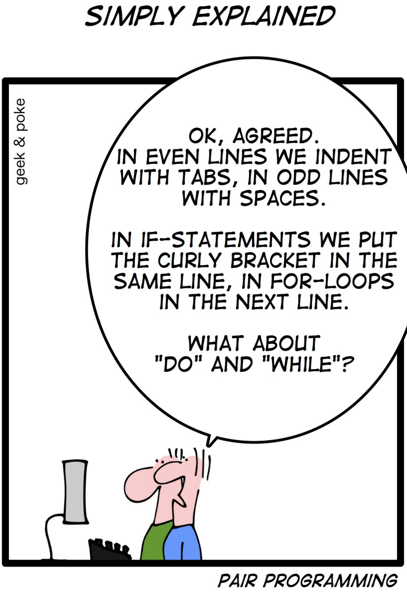
Source code formatting *or* Programming style

- Often designed for a specific programming language
- Large projects or companies usually define style

Common elements

- Layout of source code, including indentation
- Use of white space around operators and keywords
- Naming Conventions
- Use and style of comments
- Use or avoidance of particular programming constructs

Some day on Geek & Poke



http://geekandpoke.typepad.com/

Indent style

- Assists in identifying control flow and blocks of code
- Mandatory in some programming languages

Compare

```
if (hours < 24 && minutes < 60 && seconds < 60)
{
  return true;
}
else
{
  return false;
}
```

or

```
if (hours < 24 && minutes < 60 && seconds < 60) {
  return true;
} else {
  return false;
}
```

to

```
if   (     hours<
24   && minutes<
60   && seconds<
60   )
{return     true
;}          else
{return    false
;}
```

Vertical alignment

Vertical alignment is often helpful to arrange similar elements.

Compare

```
$search = array('a', 'b', 'c', 'd', 'e');
$replacement = array('foo', 'bar', 'baz', 'quux');

# Another example:

$value = 0;
$anothervalue = 1;
$yetanothervalue = 2;
```

to

```
$search      = array('a',   'b',   'c',   'd',   'e');
$replacement = array('foo', 'bar', 'baz', 'quux');

# Another example:

          $value = 0;
   $anothervalue = 1;
$yetanothervalue = 2;
```

Whitespace

- Most free-format languages unconcerned about amount of allowed whitespace
- Generally matter of taste
- Good practice: be consistent

```
int i;
for(i=0;i<10;++i){
    printf("%d",i*i+i);
}
```

```
int i;
for (i = 0; i < 10; ++i) {
    printf ("%d", i * i + i);
}
```

```
int i;
for (i=0; i<10; ++i) {
    printf("%d", i*i+i);
}
```

```
int i;
for( i = 0; i < 10; ++i ) {
    printf( "%d", i * i + i );
}
```

Tabs versus Spaces: An Eternal Holy War

People care about a few different things

1. Amount of screen columns code is indented
    - a lot of different views (mainly 2, 4 or 8 spaces)
    - might depend on context
2. How TAB characters in files are displayed on screen
    - historic: move to the right until the current column is a multiple of 8
    - many Microsoft Windows and Mac editors: same as above, but multiple of 4
    - many editors configurable
    - alternative: indent to the next tab stop (where tab stop is file-dependent)
3. What happens when the TAB key is pressed
    - possibility 1: Insert TAB character as is
    - possibility 2: Indent this line
      (cause the first non-whitespace character on this line to occur at specific column)

Tabs versus Spaces: An Eternal Holy War

People care about a few different things

1. Amount of screen columns code is indented
   Core issue - matter of taste
2. How TAB characters in files are displayed on screen
   Technical issue, interoperability
3. What happens when the TAB key is pressed
   Technical issue, interoperability

Solutions:

- Agreement within project
- Avoid TAB characters in files or, at least:
  Avoid TABS for alignment, use only for indentation

Source specific coding styles

General programming practices

Left-hand comparisons

Remove possible errors by using left-hand comparisons:

Comparison:

```
// A right-hand comparison checking if $a equals 42.
if ( $a == 42 ) { ... }
// Recast, using the left-hand comparison style.
if ( 42 == $a ) { ... }
```

Assignment:

```
// Inadvertent assignment which is often hard to debug
if ( $a = 42 ) { ... }
// Compile time error indicates source of problem
if ( 42 = $a ) { ... }
```

Looping and control structures

Use the "right" loop structure, for example:

```
i = 0
while i < 5
  print i * 2
  i = i + 1
end while
print "Ended loop"
```

vs.

```
for i = 0, i < 5, i=i+1
  print i * 2
print "Ended loop"
```

Curly brackets and loops

Use curly brackets even when not necessary (depends on language), e.g.:

```c
/* The incorrect indentation hides the fact that this
   line is not part of the loop body. */
          for (i = 0; i < 5; ++i);
/* --> */     printf("%d\n", i*2);
          printf("Ended loop");
```

or

```c
/* The incorrect indentation hides the fact that this
   line is not part of the loop body. */
          for (i = 0; i < 5; ++i)
              fprintf(logfile, "loop reached %d\n", i);
/* --> */     printf("%d\n", i*2);
          printf("Ended loop");
```

List separators

Add list separator after final element in list (where supported):

```
const char *array[] = {
    "item1",
    "item2",
    "item3",  /* still has the comma after it */
};
```

Benefit: Prevents syntax errors and subtle string-concatenation bugs after re-ordering

Language specific convention examples

C, C++

- Keywords and standard library identifiers mostly lowercase
- Macro names only in upper case with underscores
- Names beginning with double underscores or underscore and capital letter are reserved for internals of implementation (standard library, compiler)

Perl

- Locally scoped variables and subroutine names are lowercase with underscores
- Subroutines and variables meant to be treated as private are prefixed with an underscore
- Declared constants are all caps
- Package names are camel case, except pragmas (e.g. `use strict;`)

Language specific conventions

Python

- UpperCamelCase for class names
- lowercase_separated_by_underscores for other names

Java

- Class names should be nouns in CamelCase.
- Methods should be verbs, in mixed case with the first letter lowercase, with the first letter of each internal word capitalized
- Except for variables, all instance, class, and class constants are in mixed case with a lowercase first letter. Internal words start with capital letters. Variable names should not start with underscore _ or dollar sign $ characters, even though both are allowed.

Comments / Documentation

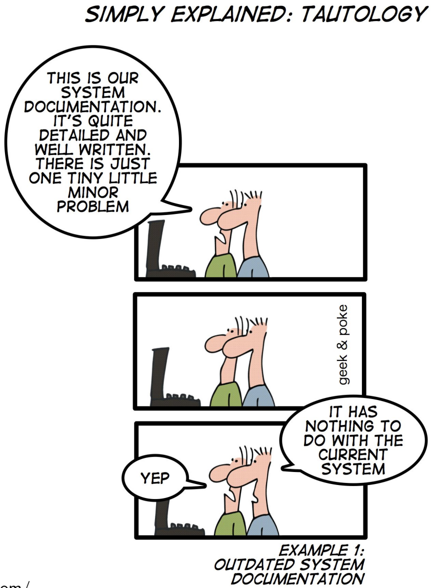
- Think about documentation before you start writing
- Update documentation regularly
- Comment often, explain what is done

```
/* compute mass from integral over rho
   as in paper xyz */
double M = 0.0;
for (int i=0; i<N; i++)
{
    M += rho[i] * volume[i];
}
```

- Don't comment the obvious

```
/* print user name */
print "$username\n";
```

Some day on Geek & Poke



http://geekandpoke.typepad.com/

Obfuscation

- Usually the opposite of good coding style
- Intellectual property protection
- Reduced security exposure
- Size reduction
- At best, merely makes it time-consuming, but not impossible, to reverse engineer a program
- Often depends on the particular characteristics of the platform and compiler, making ports difficult

$\rightarrow$ Don't do it

Obfuscation

- Usually the opposite of good coding style
- Intellectual property protection
- Reduced security exposure
- Size reduction
- At best, merely makes it time-consuming, but not impossible, to reverse engineer a program
- Often depends on the particular characteristics of the platform and compiler, making ports difficult

$\rightarrow$ Don't do it - Except for fun

Obfuscation Example

Print prime numbers less than 100:

```
void primes(int cap) {
  int i, j, composite;
  for(i = 2; i < cap; ++i) {
    composite = 0;
    for(j = 2; j * j <= i; ++j)
      composite += !(i % j);
    if(!composite)
      printf("%d\t", i);
  }
}

int main(void) {
  primes(100);
}
```

Obfuscation Example

Rewrite for as while. Use special values.

```
void primes(int cap) {
  int i, j, composite, t = 0;
  while(t < cap * cap) {
    i = t / cap;
    j = t++ % cap;
    if(i <= 1);
    else if(!j)
      composite = j;
    else if(j == i && !composite)
      printf("%d\t",i);
    else if(j > 1 && j < i)
      composite += !(i % j);
  }
}

int main(void) {
  primes(100);
}
```

Obfuscation Example

Change iteration into recursion:

```
void primes(int cap, int t, int composite) {
  int i,j;
  i = t / cap;
  j = t % cap;
  if(i <= 1)
    primes(cap,t+1,composite);
  else if(!j)
    primes(cap,t+1,j);
  else if(j == i && !composite)
    (printf("%d\t",i), primes(cap,t+1,composite));
  else if(j > 1 && j < i)
    primes(cap,t+1, composite + !(i % j));
  else if(t < cap * cap)
    primes(cap,t+1,composite);
}

int main(void) {
  primes(100,0,0);
}
```

Obfuscation Example

Obfuscate constructs and use meaningless variable names

```
void primes(int m, int t, int c) {
  int i,j;
  i = t / m;
  j = t % m;
  (i <= 1) ? primes(m,t+1,c) : (!j) ? primes(m,t+1,j) : (j == i && !c) ?
  (printf("%d\t",i), primes(m,t+1,c)) : (j > 1 && j < i) ?
  primes(m,t+1,c + !(i % j)) : (t < m * m) ? primes(m,t+1,c) : 0;
}

int main(void) {
  primes(100,0,0);
}
```

Obfuscation Example

Remove intermediate variables and literals

```c
void primes(int m, int t, int c) {
  ((t / m) <= 1) ? primes(m,t+1,c) : !(t % m) ? primes(m,t+1, t % m) :
  ((t % m)==(t / m) && !c) ? (printf("%d\t",(t / m)), primes(m,t+1,c)) :
  ((t % m)> 1 && (t % m) < (t / m)) ? primes(m,t+1,c + !((t / m) % (t % m))) :
  (t < m * m) ? primes(m,t+1,c) : 0;
}

int main(void) {
  primes(100,0,0);
}
```

Obfuscate names again

```c
void _(int __, int ___, int ____) {
  ((___ / __) <= 1) ? _(__,___+1,____) : !(___ % __) ? _(__,___+1,___ % __) :
  ((___ % __)==(___ / __) && !____) ? (printf("%d\t",(___ / __)),
  _(__,___+1,____)) : ((___ % __) > 1 && (___ % __) < (___ / __)) ?
  _(__,___+1,____ + !((___ / __) % (___ % __))) : (___ < __ * __) ?
  _(__,___+1,____) : 0;
}

int main(void) {
  _(100,0,0);
}
```

Obfuscation Example

Remove literals

```
void _(int __, int ___, int ____, int _____) {
 ((___ / __) <= _____) ? _(__,___+_____,____,_____) : !(___ % __) ? _(__,___+_____,___%
  __, _____) : ((___ % __)==(___ / __) && !____) ? (printf("%d\t",(___ / __)),
 _(__,___+_____,____,_____)) : ((___ % __) > _____ && (___ % __) < (___ / __)) ?
 _(__,___+_____,____ + !((___ / __) % (___ % __)),_____) : (___ < __ * __) ?
 _(__,___+_____,____,_____) : 0;
}

int main(void) {
  _(100,0,0,1);
}
```

Remove redundant text

```
_(__,___,____,_____){___/__<=_____?_(__,___+_____,____,_____):!(___%__)?_(__,___+_____,
___%__,_____):___%__==___/__&&!____?(printf("%d\t",___/__),_(__,___+_____,____,_____)):
(___%__>_____&&___%__<___/__)?_(__,___+_____,____+!(___/__%(___%__)),_____):___<__*__?_
(__,___+_____,____,_____):0;}main(void){_(100, 0, 0, 1);}
```

Recreational obfuscation

```
#include                                     <math.h>
#include                                   <sys/time.h>
#include                                   <X11/Xlib.h>
#include                                  <X11/keysym.h>
                                          double L ,o ,P
                                         ,_=dt,T,Z,D=1,d,
                                         s[999],E,h= 8,I,
                                         J,K,w[999],M,m,O
                                        ,n[999],j=33e-3,i=
                                        1E3,r,t, u,v ,W,S=
                                        74.5,l=221,X=7.26,
                                        a,B,A=32.2,c, F,H;
                                        int N,q, C, y,p,U;
                                       Window z; char f[52]
                                    ; GC k; main(){ Display*e=
 XOpenDisplay( 0); z=RootWindow(e,0); for (XSetForeground(e,k=XCreateGC (e,z,0,0),BlackPixel(e,0))
; scanf("%lf%lf%lf",y +n,w+y, y+s)+1; y ++); XSelectInput(e,z= XCreateSimpleWindow(e,z,0,0,400,400,
0,0,WhitePixel(e,0) ),KeyPressMask); for(XMapWindow(e,z); ; T=sin(O)){ struct timeval G={ 0,dt*1e6}
; K= cos(j); N=1e4; M+= H*_; Z=D*K; F+=_*P; r=E*K; W=cos( O); m=K*W; H=K*T; O+=D*_*F/ K+d/K*E*_; B=
sin(j); a=B*T*D-E*W; XClearWindow(e,z); t=T*E+ D*B*W; j+=d*_*D-_*F*E; P=W*E*B-T*D; for (o+=(I=D*W+E
*T*B,E*d/K *B+v+B/K*F*D)*_; p<y; ){ T=p[s]+i; E=c-p[w]; D=n[p]-L; K=D*m-B*T-H*E; if(p [n]+w[ p]+p[s
]== 0|K <fabs(W=T*r-I*E +D*P) |fabs(D=t *D+Z *T-a *E)> K)N=1e4; else{ q=W/K *4E2+2e2; C= 2E2+4e2/ K
 *D; N-1E4&& XDrawLine(e ,z,k,N ,U,q,C); N=q; U=C; } ++p; } L+=_* (X*t +P*M+m*l); T=X*X+ l*l+M *M;
  XDrawString(e,z,k ,20,380,f,17); D=v/l*15; i+=(B *l-M*r -X*Z)*_; for(; XPending(e); u *=CS!=N){
                                   XEvent z; XNextEvent(e ,&z);
                                       ++*((N=XLookupKeysym
                                         (&z.xkey,0))-IT?
                                         N-LT? UP-N?& E:&
                                         J:& u: &h); --*(
                                         DN -N? N-DT ?N==
                                         RT?&u: & W:&h:&J
                                          ); } m=15*F/l;
                                          c+=(I=M/ l,l*H
                                          +I*M+a*X)*_; H
                                          =A*r+v*X-F*l+(
                                          E=.1+X*4.9/l,t
                                          =T*m/32-I*T/24
                                           )/S; K=F*M+(
                                           h* 1e4/l-(T+
                                           E*5*T*E)/3e2
```

Summary

Essential for project success:

- Planning, Evaluation
- Integrated testing

Main Coding style issues:

- Identifier naming
- Source code formatting
- Avoidance/Use of specific language constructs

Course Work

Simple programming - testing your group

- Write a short, simple (a bit more than "hello world") program (surprise us)
- Write it well
- Compile and run at on supermike

Write short report on what you did, and commit that and source to your repo.

Deadline: **Thu Feb 27 2014**