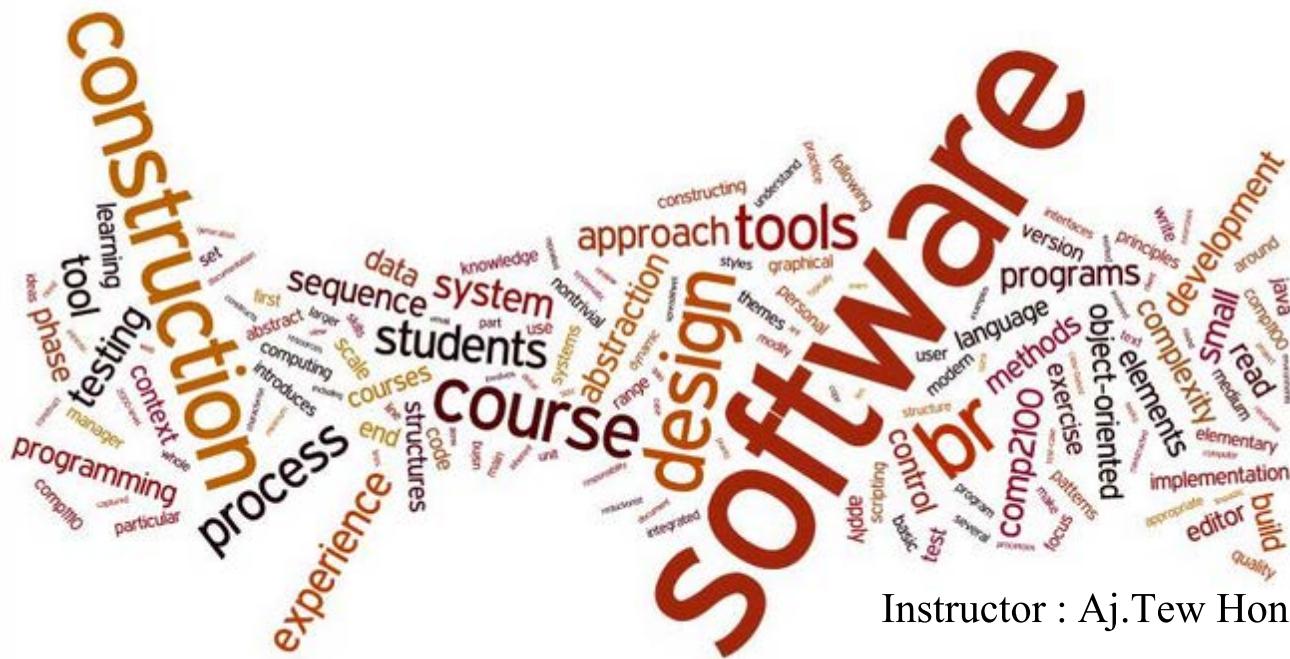




SOFTWARE CONSTRUCTION AND EVOLUTION

General Issues in Using Variables



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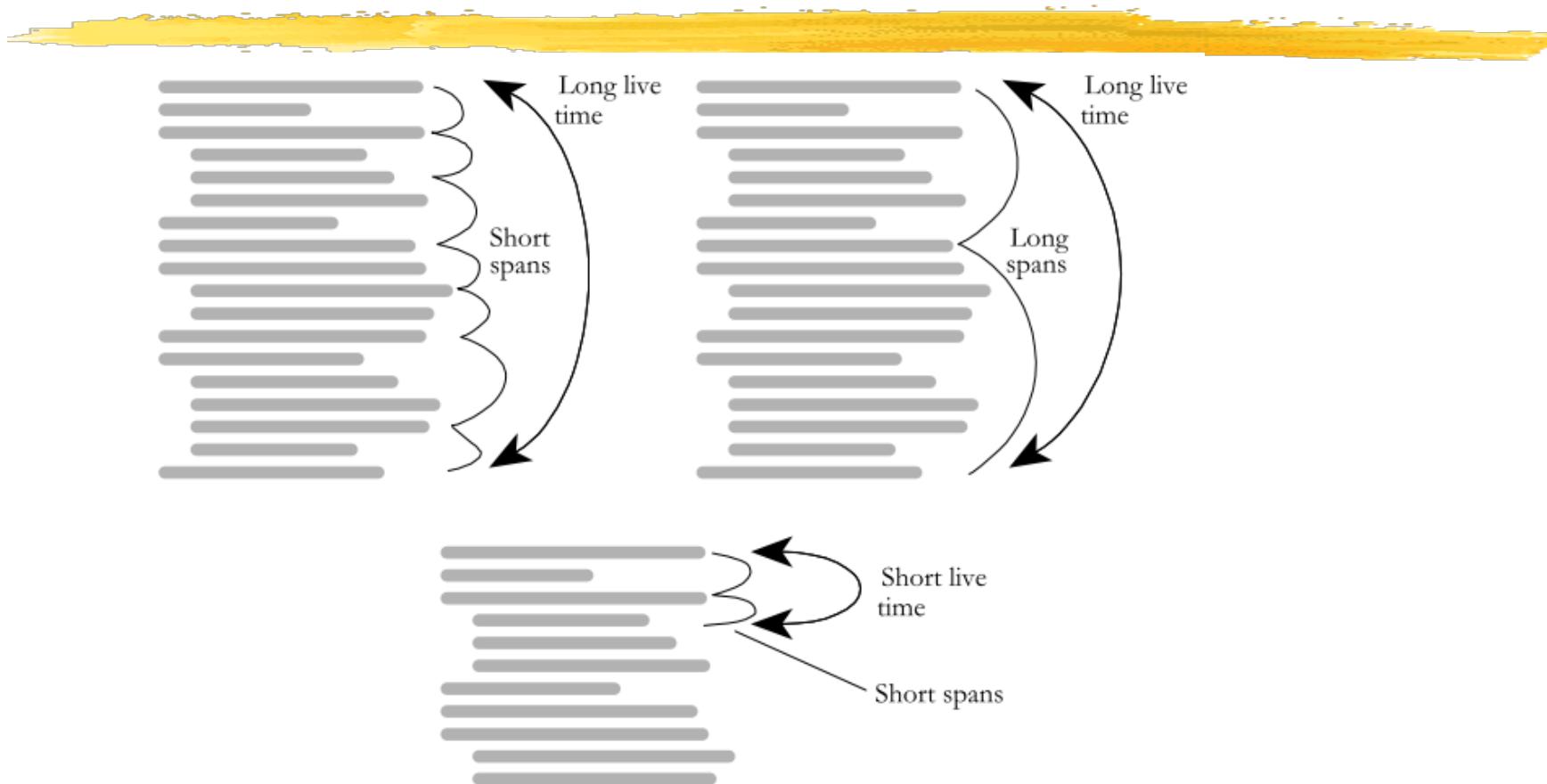
- Scope of variable
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Scope of Variables



- “Scope” is a way of thinking about a variable’s celebrity status (How famous it is?)
 - A loop index “i” is used in only one small loop
 - A table of “employee” information is used throughout a program
- “span” how close together the references to a variable used.
- Keep variable live for as short a time as possible
- A variable’s life begins at the first statement in which it’s referenced; its life ends at the last statement in which it’s referenced.

Keep Variables Live for As Short a Time As Possible



- "Long live time" a variable is alive over the course of many statements.
- "short live time" it's alive for only a few statement.
- span refers to how close together the references to a variable are.

Advantage of keeping a live time short



- Give you an accurate picture of your code.
 - If a variable is assigned a value in line 10 and not used again until line 45, implies that the variable is used between lines 10 and 45.
 - If a variable is assigned a value in line 44, 45 only, we can concentrate on a smaller section of code.
- A short live time reduces the chance of initialization errors.
 - Keeping the initialization code and the loop closer together, can reduce the chance that modifications will introduce initiation errors.

Advantage of keeping a live time short



- Make your code more readable
 - the fewer lines of code a reader has to keep in mind at once, the easier your code is to understand.
 - the shorter the live time, the less code you have to keep on your screen when you want to see all the references to a variable during editing and debugging.

Java Example of Variables with Bad Long Live Times

```
1 // initialize all variables
2 recordIndex = 0;
3 total = 0;
4 done = false;
...
26 while ( recordIndex < recordCount ) {
27 ...
28     recordIndex = recordIndex + 1;
...
64 while ( !done ) {
...
69     if ( total > projectedTotal ) {
70         done = true;
```

recordIndex (line28-line2+1) = 27

total (line69-line3+1) = 67

done (line70-line4+1) = 67

Average Live Time $(27+67+67)/3 = 54$

Java Example of Variables with Good Long Live Times

```
...
25 recordIndex = 0;
26 while ( recordIndex < recordCount ) {
27 ...
28     recordIndex = recordIndex + 1;
29 ...
62 total = 0;
63 done = false;
64 while ( !done ) {
65 ...
69     if ( total > projectedTotal ) {
70         done = true;
```

recordIndex (line28-line25+1) = 4

total (line69-line62+1) = 8

done (line70-line63+1) = 8

Average Live Time $(4+8+8)/3 = 7$

General Guidelines for Minimizing Scope



- Initialize variables used in a loop immediately before the loop
- Don't assign a value to a variable until just before the value is used

C++ Example of Good Variable Declarations and Initializations

```
int receiptIndex = 0;  
float dailyReceipts = TodaysReceipts();  
double totalReceipts = TotalReceipts( dailyReceipts );
```

General Guidelines for Minimizing Scope

- Group related statements

C++ Example of Using Two Sets of Variables in a Confusing Way

```
void SummarizeData (...) {  
    ...  
    GetOldData( oldData, &numOldData );  
    GetNewData( newData, &numNewData );  
    totalOldData = Sum( oldData, numOldData );  
    totalNewData = Sum( newData, numNewData );  
    PrintOldDataSummary( oldData, totalOldData, numOldData );  
    PrintNewDataSummary( newData, totalNewData, numNewData );  
    SaveOldDataSummary( totalOldData, numOldData );  
    SaveNewDataSummary( totalNewData, numNewData );  
    ...  
}
```

General Guidelines for Minimizing Scope

- Group related statements

C++ Example of Using Two Sets of Variables More Understandably

```
void SummarizeDaily( ... ) {  
    GetOldData( oldData, &numOldData );  
    totalOldData = Sum( oldData, numOldData );  
    PrintOldDataSummary( oldData, totalOldData, numOldData );  
    SaveOldDataSummary( totalOldData, numOldData );  
    ...  
    GetNewData( newData, &numNewData );  
    totalNewData = Sum( newData, numNewData );  
    PrintNewDataSummary( newData, totalNewData, numNewData );  
    SaveNewDataSummary( totalNewData, numNewData );  
    ...  
}
```

Using Each Variable for Exactly One Purpose



C++ Example of Using One Variable for Two Purposes—Bad Practice

```
// Compute roots of a quadratic equation.  
// This code assumes that (b*b-4*a*c) is positive.  
temp = Sqrt( b*b - 4*a*c );  
root[0] = ( -b + temp ) / ( 2 * a );  
root[1] = ( -b - temp ) / ( 2 * a );  
...  
// swap the roots  
temp = root[0];  
root[0] = root[1];  
root[1] = temp;
```

Question: What is the relationship between temp in the first lines and temp in the last few?

Answer: The two temp have no relationship. Using the same variable in both instances makes it seem as though they're related.

Using Each Variable for Exactly One Purpose



C++ Example of Using Two Variables for Two Purposes—Good Practice

```
// Compute roots of a quadratic equation.  
// This code assumes that (b*b-4*a*c) is positive.  
discriminant = Sqrt( b*b - 4*a*c );  
root[0] = ( -b + discriminant ) / ( 2 * a );  
root[1] = ( -b - discriminant ) / ( 2 * a );  
...  
// swap the roots  
oldRoot = root[0];  
root[0] = root[1];  
root[1] = oldRoot;
```

Creating unique variables for each purpose makes your code more readable.

Check List: General Considerations In Using Data



- Does the code declare variables close to where they're first used?
- Does the code initialize variables close to where they're first used, if it isn't possible to declare and initialize them at the same time?
- Do all variables have the smallest scope possible?
- Are all the declared variables being used?
- Does each variable have one and only one purpose?

Considerations in Choosing Good Variable Names

Java Example of Poor Variable Names

```
x = x - xx;  
xxx = aretha + SalesTax( aretha );  
x = x + LateFee( x1, x ) + xxxx;  
x = x + Interest( x1, x );
```

- What do *x1*, *xx*, and *xxx* mean?
- What do *aretha* mean?

Java Example of Good Variable Names

```
balance = balance - lastPayment;  
monthlyTotal = NewPurchases + SalesTax( newPurchases );  
balance = balance + LateFee( customerID, balance ) + monthlyTotal;  
balance = balance + Interest( customerID, balance );
```

- a good variable name is readable, memorable, and appropriate.

Considerations in Choosing Good Variable Names



Example:

- For a variable that represents the number of people on the U.S. Olympic team, you would create the name *numberOfPeopleOnTheUsOlympicTeam*.
- A variable that represents the number of seats in a stadium would be *numberOfSeatsInTheStadium*.
- A variable that represents the maximum number of points scored by a country's team in any modern Olympics would be *maximumNumberOfPointsInModernOlympics*.
- A variable that contains the current interest rate is better named *rate* or *interestRate* than *r* or *x*.

Example of Good and Bad Variable

| Purpose of Variable | Good Names, Good Descriptors | Bad Names, Poor Descriptors |
|---|---|---|
| Running total of checks written to date | <i>runningTotal, checkTotal</i> | <i>written, ct, checks, CHKTTL, x, x1, x2</i> |
| Velocity of a bullet train | <i>velocity, trainVelocity, velocityInTrain</i> | <i>velt, v, tv, x, x1, x2, train</i> |
| Current date | <i>currentDate, todaysDate</i> | <i>cd, current, c, x, x1, x2, date</i> |
| Lines per page | <i>linesPerPage</i> | <i>lpp, lines, l, x, x1, x2</i> |

Optimum Name Length



- On Average; 8 to 20 characters were almost as easy to debug
- Variable Names That Are Too Long, Too Short, or Just Right

Too long: *numberOfPeopleOnTheUsOlympicTeam*
 numberOfSeatsInTheStadium
 maximumNumberOfPointsInModernOlympics

Too short: *n, np, ntm*
 n, ns, nsisd
 m, mp, max, points

Just right: *numTeamMembers, teamMemberCount*

Naming Specific Type of Data



Naming Loop Indexes

Java Example of a Simple Loop Variable Name

```
for ( i = firstItem; i < lastItem; i++ ) {  
    data[ i ] = 0;  
}
```

If a variable is to be used outside the loop, it should be given a name more meaningful than *i*, *j*, or *k*.

Java Example of a Good Descriptive Loop Variable Name

```
recordCount = 0;  
while ( moreScores() ) {  
    score[ recordCount ] = GetNextScore();  
    recordCount++;  
}  
  
// lines using recordCount  
...
```

Naming Specific Type of Data



Naming Temporary Variable

- **C++ Example of an Uninformative "Temporary" Variable Name**

```
// Compute roots of a quadratic equation.  
// This assumes that (b^2-4*a*c) is positive.  
temp = sqrt( b^2 - 4*a*c );  
root[0] = ( -b + temp ) / ( 2 * a );  
root[1] = ( -b - temp ) / ( 2 * a );
```

- **C++ Example with a "Temporary" Variable Name Replaced with a Real Variable**

```
// Compute roots of a quadratic equation.  
// This assumes that (b^2-4*a*c) is positive.  
discriminant = sqrt( b^2 - 4*a*c );  
root[0] = ( -b + discriminant ) / ( 2 * a );  
root[1] = ( -b - discriminant ) / ( 2 * a );
```

Naming Specific Type of Data



Naming Boolean Variable

- Give Boolean variables names that imply TRUE or FALSE
 - *Done (true, false)*
 - *Error (true, false)*
 - *Found (true, false)*
 - *Success (true, false)*
 - *OK (true, false)*
- Use positive Boolean variable Names
 - *notFound, notdone, notSuccessful* are difficult to read when they are negated: If not *notFound*

When you should have a Naming Convention



- When multiple programmers are working on a project
- When you plan to turn a program over to another programmer for modifications and maintenance (which is nearly always)
- When your programs are reviewed by other programmers in your organization
- When your program is so large that you can't hold the whole thing in your brain at once and must think about it in pieces
- When the program will be long-lived enough that you might put it aside for a few weeks or months before working on it again
- When you have a lot of unusual terms that are common on a project and want to have standard terms or abbreviations to use in coding

Number Data Type In General



A magic number is a direct usage of a number in the code

```
public class Foo {  
    public void setPassword(String password) {  
        // don't do this  
        if (password.length() > 7) {  
            throw new InvalidArgumentException("password");  
        }  
    }  
}
```

This should be changed to:

```
public class Foo {  
    public static final int MAX_PASSWORD_SIZE = 7;  
  
    public void setPassword(String password) {  
        if (password.length() > MAX_PASSWORD_SIZE) {  
            throw new InvalidArgumentException("password");  
        }  
    }  
}
```

Number Data Type In General



Use hard-coded 0s and 1s if you need to

```
for i = 0 to CONSTANT do ...
```

is OK, and the 1 in

```
total = total + 1
```

is OK. A good rule of thumb is that the only literals that should occur in the body of a program are *0* and *1*. Any other literals should be replaced with something more descriptive.

Number Data Type In General



- Anticipate divide-by-zero errors
- Make type conversions obvious
 - $y = x + (\text{float}) i$
- Avoid mixed-type comparisons
 - $x: \text{float}, i: \text{integer} \Rightarrow \text{if } (i=x) \dots$
- Heed your compiler's warnings
 - Pay attention about complier's warning, it helps you to prevent the error

Things to consider before using Integer



- Check for integer division
 - $7/10 = 0$
 - $10*(7/10) = 0, (10*7)/10 = 7$
- Check for integer overflow

| Integer Type | Range |
|---------------------|--|
| Signed 8-bit | -128 through 127 |
| Unsigned 8-bit | 0 through 255 |
| Signed 16-bit | -32,768 through 32,767 |
| Unsigned 16-bit | 0 through 65,535 |
| Signed 32-bit | -2,147,483,648 through 2,147,483,647 |
| Unsigned 32-bit | 0 through 4,294,967,295 |
| Signed 64-bit | -9,223,372,036,854,775,808 through 9,223,372,036,854,775,807 |
| Unsigned 64-bit | 0 through 18,446,744,073,709,551,615 |

Things to consider before using Floating



Avoid additions and subtractions on numbers that have greatly different magnitudes

$1,000,000.00 + 0.1$ probably produces an answer of $1,000,000.00$

because 32 bits don't give you enough significant digits to encompass the range between 1,000,000 and 0.1.

Things to consider before using Floating

Avoid equality comparisons

Java Example of a Bad Comparison of Floating-Point Numbers

```
double nominal = 1.0;
double sum = 0.0;

for ( int i = 0; i < 10; i++ ) {
    sum += 0.1;
}

if ( nominal == sum ) {
    System.out.println( "Numbers are the same." );
}
else {
    System.out.println( "Numbers are different." );
}
```

| |
|---------------------|
| 0.1 |
| 0.2 |
| 0.30000000000000004 |
| 0.4 |
| 0.5 |
| 0.6 |
| 0.7 |
| 0.7999999999999999 |
| 0.8999999999999999 |
| 0.9999999999999999 |

Things to consider before using Floating



Java Example of a Routine to Compare Floating-Point Numbers

```
double const ACCEPTABLE_DELTA = 0.00001;
boolean Equals( double Term1, double Term2 ) {
    if ( Math.abs( Term1 - Term2 ) < ACCEPTABLE_DELTA ) {
        return true;
    }
    else {
        return false;
    }
}
```

Kinds of names to avoid:



- **Avoid misleading names or abbreviations.**

As FALSE as abb for "Fig and Almond Season."

- **Avoid names with similar meanings.**

As fileNumber and fileIndex.

- **Avoid variables with different meanings but similar names.**

As clientRecs and clientReps.

- **Avoid names that sound similar.**

As wrap and rap.

- **Avoid numerals in names.**

As file1, file2.

Kinds of names to avoid:



- **Avoid words that are commonly misspelled in English.**

As occassionally, accumulate, and ascend.

- **Don't differentiate variable names solely by capitalization.**

As count and Count.

- **Avoid multiple natural languages.**

As "color" or "colour".

Do details like these really matter?



Programmers over the lifetime of a system spend more time reading code than writing code.

Example for Low Quality Coding!! (C++)

```
void HandleStuff( CORP_DATA & inputRec, int crntQtr, EMP_DATA empRec, double
    & estimRevenue, double ytdRevenue, int screenX, int screenY, COLOR_TYPE &
    newColor, COLOR_TYPE & prevColor, StatusType & status, int expenseType )
{
    int i;
    for ( i = 0; i < 100; i++ ) {
        inputRec.revenue[i] = 0;
        inputRec.expense[i] = corpExpense[ crntQtr ][ i ];
    }
    UpdateCorpDatabase( empRec );
    estimRevenue = ytdRevenue * 4.0 / (double) crntQtr;
    newColor = prevColor;
    status = SUCCESS;
    if ( expenseType == 1 ) {
        for ( i = 0; i < 12; i++ )
            profit[i] = revenue[i] - expense.type1[i];
    }
    else if ( expenseType == 2 )  {
        profit[i] = revenue[i] - expense.type2[i];
    }
    else if ( expenseType == 3 )
        profit[i] = revenue[i] - expense.type3[i];
    }
```

Find at least 10 different problems with it!

7. Only CORP_DATA is used!!

```
void HandleStuff( CORP_DATA & inputRec, int crntQtr, EMP_DATA empRec, double  
    & estimRevenue, double ytdRevenue, int screenX, int screenY, COLOR_TYPE &  
    newColor, COLOR_TYPE & prevColor, StatusType & status, int expenseType )  
{  
    int i;  
    for ( i = 0; i < 100; i++ ) {  
        inputRec.revenue[i] = 0;  
        inputRec.expense[i] = corpExpense[ crntQtr ][ i ];  
    }  
    UpdateCorpDatabase( empRec );  
    estimRevenue = ytdRevenue * 4.0 / (double) crntQtr;  
    newColor = prevColor;  
    status = SUCCESS;  
    if ( expenseType == 1 ) {  
        for ( i = 0; i < 12; i++ )  
            profit[i] = revenue[i] - expense.type1[i];  
    }  
    else if ( expenseType == 2 ) {  
        profit[i] = revenue[i] - expense.type2[i];  
    }  
    else if ( expenseType == 3 )  
        profit[i] = revenue[i] - expense.type3[i];  
}
```

1. Bad Name!!

5. Doesn't defend itself against BAD data!! (crntQtr = 0! Error!)

2. Input variable is changed!

3. Read&Write Global Variable (corpExpense, profit)

4. Not Single purpose
- Write to DB, Calculate Xxx

6. Magic Number!! 100, 4.0, 12, 123?