Lec 1

Abstraction
Removing(or hiding) unnecessary complication/detail
Good: Array.Sort();
Bad: nested for loops etc.

Abstraction Levels
Programming Languages(Assembly low) ← High
Compiler
OS
Architecture
Circuits
Physics ← Low
API- Defines operations (and efficiencies)

API-Application Programming Interface
High level specs of ops, e.g. Array, Add, Remove, Contains, IsEmpty, Graphics.Draw, etc.

Levels within Programs
API ← High
Classes/Data Structs
Functions/Methods
Variables/Statements
Types/Operators ← Low

Software Practices Stepps
1. Analysis – what do we need to do?
2. Design – how do we do it?
3. Implement it - Coding Yay!
4. Test, debug, improve
5. Go back to 1-4 as needed

Why Comment/Document?
Your code (in the RW™) will outlive you. Make your successor's life easier Make your (future) life easier

Lec 1 (cont)

XML Syntax
<tag> info </tag> e.g.,
<summary> … </summary
<param name='val'> … </param>

When to Comment?
ALL files must have a header comment!
ALL methods must have a header comment
All fields/properties should have a comment

Why XML?
Machine readable, parsable, intellisensable

C# source files can have structured comments that produce API documentation for the types defined in those files. The C# compiler produces an XML file that contains structured data representing the comments and the API signatures. Other tools can process that XML output to create human-readable documentation in the form of web pages or PDF files, for example.

Lec 2

Delegates
A delegate is a way to provide a TYPE for a function return type, parameter list/types
You can use delegate types to store functions in variables "call" those saved functions using the variable name

Lec 2 (cont)

Delegates are fully object-oriented, delegates encapsulate both an object instance and a method.
Delegates allow methods to be passed as parameters.
Delegates can be used to define callback methods.
Delegates can be chained together; for example, multiple methods can be called on a single event.
Methods don't have to match the delegate type exactly. i.e. Variance in Delegates.

Delegate is the definition of the "Type" of function. Lookup is just a name I choose!

Example public delegate int Lookup(string name);

Delegates as Params
Delegates allow you to "pass" functions to other functions int doit(string x){ … } // ← Meets Delegate Requirements
…
Evaluate("1+var", doit)

Lec 3

C# Similarities w/ Java
Compiled to an intermediate form Run with a "runtime environment"
Automatic memory management
Syntax mostly the same (or one-to-one transition)

Lec 3 (cont)

C# Differences w/ Java
C# functions are "first-class" (see delegates)
Generics can use primitives (List<int> vs. <Integer>)

C# Access Modifiers
public, protected, and private are the same as in Java.
Internal means any method in the compilation unit (e.g., project) can treat the variable as public, but "outside" users treat it as private.
Why do we have these?
Answer: Because programmers are human and programming is hard. These modifiers "say": Only allow the person most familiar with the code to make changes to data; e.g., the library code itself has private variables (such as the stacks) and only the person writing that code "knows enough" to use them. The "outside world" user just uses the Evaluate method.

Readonly declaration
readonly int max_stack_depth = 5;
"variable" can only be set in constructor (or in field declaration)

Interfaces
Same as java
Contract for a method (somewhat like a delegate)

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Lec 3 (cont)

Namespaces

Keep common terms separate e.g.,
namespace Math { public Vector{...} }
namespace Collections { public Vector { … } }
Requires “using” statement
using Math;

Escaped Strings

How do you put a “new line” into a string?
Answer: “\n” The \ (back slash) is called the “Escape Character”
Used to combine “regular characters”, i.e., ‘n’ and ‘\’ to form a special character
Common escaped characters: /t, /n, /e
Example: string filename = “c:\\documents\\files\\abc.txt”;
Note: Unix uses slashes, so you don’t have to “double up”: (e.g., /home/germain)

Verbatim Strings

Use the @ symbol
Escaped strings are ugly :(hard to read)
Remove some of the ugliness: string filename = “c:\\documents-\\files\\abc.txt”; vs. BAD: string filename = “c:\documents\files\a-bc.txt”; GOOD: string filename = @“c:\documents\files\abc.txt”;
Useful sometimes in regular expressions

Lec 3 (cont)

Interpolated Strings - $

Do This! (Almost always!)
How do you put variable values into a string?
Old, Bad way: string s = “Your score of ” + score + “ is a good one!”;
New, Good way: string s = $“Your score of {score} is a good one!”;

Solutions & Projects

Solution → Spreadsheet
Contains:
Projects FormulaEvaluator (Library Application)
FormulaEvaluatorTester (Console Application)
Projects Contain:
code files, etc.
Contain References to other projects/libraries
Tester must “reference” FormulaEvaluator

Lambdas

Shorthand notation for: Defining small anonymous functions Inline
Useful for: Testing, “One offs”, Some GUI applications, etc.
Syntax:
([param1, param2, …]) => { code };
([param1, param2, …]) => expression to return;

Lec 4

Version Control Use

Collaborative development
Branching/Merging Code archeology/File history
Differences
Backup

GIT Functions

Committing: Save work as a “Version” with a “Message”
Branching: Try something else out which may or may not come back into the main branch later via Merging.
Push/Pull: Send changes from one place to another
TAG: Like a “bookmark” to find a particular state of your code
Code History: Compare one Commit to Another
Diffs Split vs. Unified

Extensions

Extensions allow us to add “dot methods” to classes we don’t own, use this new functionality as if it is “built in”
Example: name.CapitalizeFirstLetters( );

Lec 4 (cont)

IEnumerable

Guarantees that something is countable and can be iterated over Arrays, Lists, Trees, Dictionaries, etc ← all are IEnumerable
Can convert the above to “base” types using: toList, toArray
Allows support for: foreach loop
Has a templated type
Is an Interface: GetEnumerator
Current (array → int current = 0;)
MoveNext (array → current++;)
Reset() (array → current = 0;)

Interface

A specification guaranteeing that an implementing class will have certain functions
Guarantee made by the compiler
There is no guarantee the functions work, just that they are there.
Aside: Useful also with Polymorphism:
Movable x; // A Movable must have a .move() method
Car c = new Car();
x = c; // public class Car : Movable
x.move(); c.move()

Enumerator

Enumerator is an object that allows iterating over the object

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Lec 4 (cont)

IEnumerable

A high level type (interface) that allows us to apply actions to a list of objects
Useful with foreach loop
Useful when we don't care (or know) the underlying data structure
Makes our code more robust and general!

Lec 5

Unit Tests

Test the "smallest" pieces of the software system {[nl]}E.g., methods
Simplifies tests, simplifies debugging
"Easy" to find the failure point

Self Contained Testsing

Tests should not rely on "outside" state
Test should:
define data (e.g., build a Dependency Graph)
Execute algorithm (e.g., remove/add dependencies)
{[nl]}Verify (e.g., using asserts)

Code Review

Higher Quality Code
Fewer Defects
Easier to Maintain
Developer Training Learn about other parts of codebase Learn about other techniques

Lec 6

Immutable

Strings are immutable, they cannot change.
Thus once we write:
string s = "jim";
That string object will _always_ contain "jim"
Question: s = "jess" does not change the string, but instead creates a reference.

Mutable

Example: a stack is mutable (it can be changed),
Stringbuilder class allows us to modify strings

Methods that Modify(Mutate) an Object

are called mutators
The stack class is "Mutable"
Can be modified after creation
The string class is "Immutable"
Cannot be modified after creation
Q: How can you make any object Immutable (to a programmer using your object?)
A: Make all fields/Properties/-setters PRIVATE! (protected)

Lec 6 (cont)

Properties

C# has a convenient notation for building getters/setters
Can control public/private of get and set independently
Often properties are "backed" by private member fields
As always, member fields should default to private
"private" properties can often just be private member variables
Example:
a private property could be used for lazy instantiation of an expensive field: e.g., private password (get ☐ if passwo-rd==null, do expensive password get operation)

Lec 6 (cont)

Properties

Properties are similar to named fields in the object
Properties should be aspects of an object that can be understood independently of the rest of the representation
Think, for example, of the current hour of the day (from a Date class where internal representation is seconds since a prior date)
Public properties (which is usually the case) provide a "contract" with user of your code
Has a convenient notation for building getters/setters{[nl]} Can control access to get and set (i.e., private) independently
As always, don't make every member variable public
"private" properties can often just be private member variables

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Lec 6 (cont)

Func v.s. Delegate Notation

If you aren't going to have (1) any useful/descriptive words, or (2) Or it is a "one off" then use "Func" notation

delegate int MathOnTwoNumbers(int x1, intx2);

int add(int a, int b) { … }

AddTwoNumbers f1 = (a,b) => a+b; // lambda to fulfill Delegate

Func<int,int,int> f2 = (a,b) => a+b; // lambda to fulfill Func

AddTwoNumbers f3 = add; // regular function to fulfill Delegate

Func<int,int,int> f4 = add; // regular function to fulfill Func

Delgate v.s. Func

Why Use Delegate?

Named, Documented, Provides More Context

Evaluate(string formula, VariableLookUpMethod lookup)

Why Use Func?

Shortcut, Types are "right there to see"

Evaluate(string formula, Func<string,int> lookup)

Lec 7

Global Variables

Data that is accessible from "anywhere" in the program

If a method modifies one, it is a "hidden side-effect"

Software Practice - Almost always:

Best Case: Data → Function → return New Data

Nothing else changes!

Okay Case: Data → Function → parameters "change" (see out/ref params)

Lec 7 (cont)

Memory

Stack

Methods (and their Variables)

Heap

Objects

Methods go on the Stack

Variables in Methods go on the Stack

Objects go on the Heap

Changing something about a "Shared" (Aliased) variables is "seen" by all other aliased variables

Memory Diagram

Every function should be labeled on the stack

Every variable is kept on the call/activation stack

References (to objects) have "arrows" to heap

Value variables have values on stack

Object methods should show "this" explicitly on the stack

Every new object is kept on the heap

Pass by Value & Ref

By Value

- a copy of the value is added to the stack frame of the called method

By Reference

- a "pointer" to the object is added to the stack frame of the called method

Lec 7 (cont)

In, Out, Ref Params

In

- makes Reference constant

WARNING: does not make object constant

Out

- refers to calling methods variable

Places object "in" calling methods variable

Must be assigned a value

Cannot use "what was there before"

Ref

- refers to calling method variable

Can use what is there

Does not have to assign a value

Out and Ref the same except compiler enforces semantics

Structs

Structs are like VALUE types

They go on the Stack

Unless part of an object

Let's Draw a picture for

struct Pt { int x; int y; } main() { Pt pt1 = new pt(); Pt pt2;

Structs

Constructors allowed, but not required

new() → calls constructor

Does not put object on heap

Can have methods

Getters/Setters/Properties

Usually do not!

Why do structs go on the stack?

Efficiency!

No allocation!

No deallocation/Garbage Collection.

Lec 7 (cont)

Memory Efficency

the closer the data is to the CPU the faster the memory (and the more costly, thus there is less of it)

Lec 8

IEnumerable

What is the "High Level English" meaning of an IEnumerable?

Guarantees a "list" of "stuff" coming back.

What are some classes that implement IEnumerable?

List, HashTable, BST, Array, etc.

IEnumerable iterable = new BST();

IEnumerable iterable = new List<string>(…); // etc

What does an IEnumerable "give you"?

A way for OUTSIDE CODE to "walk" the data:

foreach (var item in iterable) { Print(item); }

IEnumerable uses an Enumerator

Implemented by an Enumerator Class

Enumerator has low level functionality

Bool ← MoveNext // if there is another item, return true

Current // return the current item

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Lec 8 (cont)

Linq

Adds “Database-like” syntax to C# (somewhat modeled on SQL database language).
Can convert IEnumerable to Arrays or Lists
Using System.Linq;
public void doit(IEnumerable container) {
List list = container.ToList();

Yield Return

C# has a way to Only partially execute a function
Can later return and complete more of it later!
This is called: Yield Return
Yield Return SAVES the entire execution state of the method call (i.e., the call (activation) stack) for continued execution at a future point!

Yield Return Explained

When the line with yield return is encountered:
The runtime saves the entire STATE of the method
Local Variables
Parameters
When the method is called again, the runtime restores the state and continues
From the last point of execution!

Lec 8 (cont)

Why we need Yield Return

Example: Imagine a GUI with a button that populates a textbox with the next prime.
static IEnumerator iterator = next_prime().GetEnumerator(); // actually need Enumerator
void button_action()
{
iterator.MoveNext(); // hidden: computes next prime and saves state of method
text_box.Text = iterator.Current;
}

REGEX

[abc] ← Square Brackets: match any character in here
a|b ← OR - Match an ‘a’ or ‘b’ character
a ← *Match zero or more (little) a’s*
d+ ← Match one or more (little) d’s
\d+ ← Escape: Match one or more digits!
\s ← Match whitespace
a? ← *Match zero or one little a’s*
(a) ← If we find this, put it in “group” 1
a$ ← a at end of string!

Lec 8 (cont)

Yield Return

Use when you either
CANNOT create entire list of results
TOO COSTLY to create entire list of results
Need to SPREAD computation over longer time Might not need all values!
Question: Binary Search Tree with Nodes
{ Node left; Node right;}
How would you build the iterator?
Answer: yield return can use recursion!

Yield Return BSTpseudocode

IEnumerable traverse(Node current)
{
if (current == null) return;
yield return this.Value;
traverse (this.left);
traverse (this.right);
}

Func ⇔ Delegate shortcut

public delegate string Normalize(string); // Definition
Normalize function = s => s; // Usage with Lambda
Func<string,string> function = s=> s; // Func notation
Func is simply inline (shortcut) notation for delegates without a name.

Lec 8 (cont)

What does == do?

== is REFERENCE equality
Are X and Y the same object in memory.
overloaded ==
Can mean anything you want it to mean, but…
Usually means VALUE equivalence “jim” == “jim”
.Equals
Means value equivalence

DRY -Don't Repeate Yourself

Dry is a fundamental principles of good software development
Don’t repeat Data!
Violate sometimes for speed (can be a good reason)
Don’t repeat Code!
Violate sometimes because we are lazy (bad reason)
Example: using extensions is a good dry practice

Dry Code

Move common code to helper method(s) Make Library for common code Use Extensions Library

What is an Invariant?

A condition that must always be true.
For example:
If A1 depends on B1
Then B1 must have A1 as a dependee

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Lec 8 (cont)

How do we ensure the Invariant on this?
public void ReplaceDependents(string s, IEnumerable<string> newDependents) { }
Answer: this function should not touch Map 1 or Map 2 Answer 2: this function should only use addDependency and removeDependency

MVC
Model - Data (and some methods to compute on data)
View - What the user sees
Controller - Interactions between User and Model

NameSpaces
SpreadsheetUtilities
Internal namespace to your project for your use/protection
SS ← Added to project now
External namespace your project “shows” to the world, similar to System, or Math, or Collections…

Lec 9

Abstract Class
Defines WHAT must be done (via methods)
Defines Return and Parameter Type Signatures
Defines generic (reusable) code
Defines generic data (if applicable)
A child class can only implement one
Can have a constructor

Lec 9 (cont)

Interfaces
Defines WHAT must be done (via methods)
Defines Return and Parameter Type Signatures
No Code
No Data
A class can implement many
No constructor

MVC
Model - Working on this now
Data→ Cells - Contents / Values
Functionality → Dependencies (See requirements in Abstract class)
View - GUI (not working on this now)
Controller - actions available to user
often initiated through the GUI
Not working on this now

Why Comment?
Shows that you understand your code
Allows partners and future developers to understand your code before reading it line by line
Can be used PRIOR to coding to set specifications/reminders
Can be “scraped” to provide external documentation

<inheritdoc>
Does just that. {[nl]}Inherits documentation from parent (class)
Why is this DRY?
DRY since we don't repeat ourselves/code

Lec 9 (cont)

How/When to Comment
Header Comment vs. Inline
Header - High-level overview of desired functionality
Don’t “re-write” code in comments
Question: What is “comment rot”?
Inline
For sections of a long function (alternatively, helper methods)
For tricky code
Use descriptive variable names to alleviate the need for some comments

Self-Documenting Code
Wrong - “Don’t Comment your Code!”
Right Comment for Why
Provide links to algorithms, examples, docs
Rename complicated expressions with understandable names

Lec 9 (cont)

DRY
Do not repeat yourself
Do not repeat code
Use helper methods
Do not repeat data*
Transform requests/inputs into a single standard form
Question: when “can” we repeat data
Answer: in a very local location (e.g., a single class file) where invariants are set (e.g., input into the dependents always updates dependees) and only if we get a strong efficiency boost that (in your expert opinion) is worth the SE hit.

Yield Return
Used for Enumerations (IEnumerable)
Operationally: Saves Code/Method Call Stack
Used for: “infinite” or “costly” enumerations

Lec 10

GSP- Good Software Practices
Good use of Versioning
Multiple Commits. Good Commit Messages
Tags at “Releases”
Good use of Testing
Extensive Unit Tests
Well named/useful tests.
Documentation
READMEs
Located in Solution Folder (and all Project Folders)
Hour tracking
Software Practice Section
Header Comments
Who, what, verification
Method and Field Documentation

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Lec 10 (cont)

Diagrams

Intrinsically encode:
Basic functionality of each piece
How pieces fit together to form the whole
Overall design philosophy

UML -Unified Modeling Language

Unified Modeling Language
"Syntax" for drawing diagrams
Programming Language agnostic
Not all fields/methods need to be shown
Only those required for an understanding

UML Visibility Modifiers

- private
+ public
# protected
underline static

Connectivity

Arrow indicates that one class is aware of another Direction indicates whom is aware of whom

Aggregation

Something is composed of independent entities
When the "container" goes away, the entities do not ("weak" ownership)
e.g. A Course containing Students, but the students don't "go away" when the course is cancelled.

Lec 10 (cont)

Composition

Entities within are not whole on their own ("strong" ownership)
e.g. A Student containing a Transcript, and the transcript "goes away" when the student leaves the University

Diagrams

UML:
Formal
Persistent documentation
"Suggests" more information
Whiteboard:
Less Formal
Might be erased
Likely to "miss" information
This information is likely to be somewhere else (API file)

Incremental Testing

Test incrementally!
The longer you go without testing, the bigger your "haystack" becomes
Catch design flaws early
Problems will become apparent before bolting it all together
Keep the "haystack" small!
Testing is a lot like debugging

Complex Systems

Butterfly effect
Even for a tiny change in an obscure region of the code Run the test suite!

Lec 10 (cont)

Regression Testing

Regression refers to "going backward" (regressing)
When new code is added the number of bugs goes up, therefore the code "regresses"
Try to minimize this
Run existing (old) tests regularly
As code changes, tests might start failing
Note: Sometimes the Test needs to be updated
Test suite continuously grows
Never discard a valid test!
Must start test suite on "day one" or it won't get done
Must keep tests up to date (prioritize them)
Or it won't get done
Must run tests every day
Or it won't get done!

Smoke Tests

Subset of full suite
should run in < 5 minutes
if your entire suite runs quickly, use them all!
Try to pick broad range of coverage
Run them after every compile

Lec 10 (cont)

Code Coverage

100% coverage is often difficult
Huge systems – countless paths
Irregular interaction (e.g. GUIs)
That being said:
"Model" code is easier to cover
Eliminate "dead" code
You have access to the "white box"

Gray Box Tests

Combine Black Box and White Box
First, design tests of the specification (black)
Then, design tests for code coverage (white)
Keep them both in a test suite

Debug Assertations

Assertations in regular code:
Debug.Assert(some condition);
Condition should always be true – fails otherwise
Sprinkle these throughout your code where invariants should hold
Get removed in release builds – important for performance!
Use them if your code assumes preconditions
Good use of assertions can save countless hours of debugging
Fail Fast!

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Lec 10 (cont)

Variable/Object Review

An “empty” (class) variable is a placeholder for an object

An “empty” (value type) variable is a value

For example:

int x;

Student s;

Explicit Nullables Syntax

? - The Question Mark is used to denote that a variable is allowed to contain nulls:

How to use Explicit Nullables

If there is a case where you may need a variable or parameter to contain nulls, write it like so:

public Student? function(Student? s) // s may contain null

{

Student? temp = s; // temp may contain null

…

return temp;

}

How to use Non-Nullables

Non nullables REPLACE the old syntax:

public Student function(Student s) // s must contain an object

{

Student temp = s; // temp must contain an object

…

return temp; // temp cannot contain null (compiler enforced)

}

Lec 10 (cont)

Nullables

Summary:

Class c;

Good software practice: do not allow variable to contain null values

OLD way - code does not enforce this (in fact it implies c contains null)

NEW way - code/compiler enforces

Therefore Class? c = null; // allows null

Class c = new(); // does not allow null

Enforced by compiler for a given Project!

Lec 11

Testing

Coverage != Good Tests

Necessary but Not Sufficient

Tests should be small and targeted

(Hence Unit Tests)

A _deep_ understanding of the project goals is very important to understanding the code

A full reading of all specifications (both in the starter code and written documentation) is necessary!

Stress Tests show correct use of complexity/big O

Harder to write

Harder to debug

Lec 11 (cont)

Information Storage and Retrieval

Saving and restoring information is fundamental to real programs

Solutions:

Files ← Old fashion (but still useful ;^)

XML/JSON/ETC

Databases ← Modern

SQL/MySQL/Mongo/SQLite/Firebase/etc

Saving Files

Need a “protocol” (i.e., what does a file structure mean?)

XML and JSON

Notations for saving information

Machine readable

Supported by Abstractions and Libraries

Using Statement

Forces “cleanup”!

Operating System must close file

Try renaming a file while Visual Studio is open with it

Advice for CS 3505

C++ → Destructor

All objects have an explicit action they take when they are no longer referenced/used

Translates into:

Try

Finally

(always done regardless of exception status)

Can only be used on Disposable Objects

Should always be used on Disposable Objects!

For Files, the finally closes the file stream!

Lec 11 (cont)

XML-Attributes

Attributes - inside of tag < >s

Add extra information to tag

Probably should be avoided (most of the time*)

Examples:

<teacher name=“Jim">

<param name=“length”>

<list type=“number”>

<record id=“57”>

JSON vs. XML

JSON newer;

XML older;

Both “do the job”

Both machine readable/parsable

Same abstractions

JSON ← Many (? most ?) Web applications use this

JSON

JSON – Representation – Object is {}

Key Name/Value:

{ “key” : “value” }

Value can be a JSON object

{ “key” : { key1 : value, key2 : value } }

JSON Arrays:

{ “key” : [{ key: value, … }, { … }, …] }

Reflection

Computer language can inspect runtime objects

Field Names

Types

Etc

Serialization

Uses Reflection to determine Run-Time structure of object

Turns this structure into a machine readable format

Can do this automagically

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Lec 11 (cont)

XML Serialization

You can either use the sample code (with small modifications) As many programmers before you have done
Read documentation on XML serialization and use this technique

Properties vs. Fields

Serialization works on Properties instead of fields
Field: int name;
Property: int Name { get; set; }
Warning
Default serialization works on public Properties.
If you want Private access, or to change the names, you must use some “meta-tags”

Lec 12

Business Logic

Where does the business logic error checking go?
M, V, or C ?
Answer:
Model and Controller (mainly) but also in the View! ←Trick Question!
Example:
Model checks for cycles in graph
Controller does input sanitization
View only allows inputs in valid cells; View restricts input to only numbers (where appropriate)

Lec 12 (cont)

Spreadsheet ⇔ MVC

Which of the following is a Model, a View, or a Controller?
FormulaEvaluator - Model
DependencyGraph - Model
Formula - Model
Spreadsheet - Model
GUI - Controller and View

GUI

Real world programs (usually using GUIs) are driven by inputs
Unpredictable (based on human input)
Execution is non-deterministic
You don’t know the order of the users actions…

Design Pattern: Notifier ⇔ Listener

Event: any occurrence that may require action by “someone” else
Making sure the “right event” gets to the Right place is challe-nging!
Listeners: “subscribe” to an event
Notifier: “sends” the event
Listeners take action upon “hearing”

Lec 12 (cont)

C# Event Handling

Note: Directly supported by the language!
Define a delegate for handling the event
All handlers match this signature
Declare an event (in the notifier)
Register a handler (in the listener)
Trigger the event (in the notifier)

C# Events

First, define a delegate for handling the event:
delegate void CancellationEve-ntHandler();
All handlers must match this signature!
void return – No Parameters!
Next, declare an event (in the notifier):
class University {
event CancellationEventHandler canceller;
// Keyword Type Field Name

Event Abstraction

The event syntax provides:
a list
a foreach loop
an assignment operator
All “hidden” (abstracted) with simple/compact syntax!

Lec 13

Good Software Practices

All of the techniques and principles (e.g., DRY) that we discuss are designed to give developers “Best Practices” for creating code that:
a. Contains fewer defects
b. Is more maintainable
Easier to understand
Easier to modify
Safer to modify (see (a) above)

SOLID Code

Single Responsibility
Open-closed principle
Liskov substitution principle
Interface segregation principle
Dependency Inversion

(S)ingle Responsibility

Each class (dare we say even method) should have a single responsibility
Example: the spreadsheet model does not deal with:
The GUI
Dependency Graph
(Other than by using the DependencyGraph library)

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Lec 13 (cont)

(O)pen-Closed Principle

Best practice is NOT to modify existing code.
Why?
Added functionality is added by "extending"
Inheritance
Subclassing in C#
Extension (void doit (this Type, params) { })
Example: stack class is not re-written but helper methods, such as "IsOnTop", are added

(L)iskov Substitution Principle

Variables in a program of a give (Parent) type should be replaceable with instances of their subtypes without altering the correctness of the code.
Example: The need for an Abstract Spreadsheet can be fulfilled with any students Spreadsheet implementation

(I)nterface Segregation Principle

Many small interface specifications are better than one large one
"Child" classes can implement multiple interfaces as necessary
Not a good example from Spreadsheet
Example: IDisposable
Only one method – Dispose

Lec 13 (cont)

(D)ependency Inversion Principle

Classes should depend upon Abstraction not Concreteness.
Where possible, variables/fields should be Interfaces or Abstract Classes rather than a concreted class.
Example: Spreadsheet GUI should have an Abstract Spreadsheet member variable, not a Spreadsheet.
This allows flexibility in expanding the project in the future

```
class GUI
{
private Spreadsheet Spreadsheet; // WRONG
private AbstractSpreadsheet Spreadsheet; // CORRECT
```

How do you"start" becoming a better software engineer?

Q: How do we get all of this "stuff" into our program.
Suggestion:
Concentrate on the S (single responsibility)
Remember the O (open/closed) when using other code
Try to remember to define (and use) Interfaces
Upon modifying (adding features to) the code, refactor to increase SOLIDness
As you grow more skilled, consider SOLID from the start

Lec 14

Software Practice and Parallel

Does Parallel make code easier to understand?
Does Parallel make code have fewer defects?
NO!
It might inspire you to better document, but it is intrinsically more complicated than single thread execution
So why do we do it?
Answer: efficiency gains out weight complexity
We must be even more diligent in our naming, documentation, testing, etc., when writing parallel code

Moore's Law

•Gordon Moore, 1975:
Transistor density will double every 2 years
What does this mean?
• It does not mean: processors get 2x faster every 2 years

Dennard Scaling

Robert Dennard, 1974: As transistors shrink, power-density remains constant
•What does this mean?

Moores + Dennard

•What does this NOT mean?
• That computers automatically get faster
•What does this mean?
• In part, it means we're getting lots of cores
•We have to figure out how to use those cores!

Lec 14 (cont)

Parallel Computing

•We told the algorithm how to divide the work
•And more importantly, how to combine the results
•Writing code without thinking about parallelism will not (usually) produce a parallel solution

Thread

•Thread: a single sequential subprocess
• Almost like its own program
•Multi-threading is the ability of a computer to execute multiple threads concurrently

Non-Blocking

•thread.Start() is a non-blocking statement
• It returns right away
• Even though the other thread is still running
•thread.Join() is blocking
• Calling thread waits until thread finishes
• What defines when thread is finished?
• When the work function returns

Timing

•You can not make any assumptions about how long some computing operation will take
•With concurrency, there is no guarantee about the order in which events occur

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Lec 14 (cont)

Concurrent

•Concurrent
• Multiple tasks running
• Thread can be interrupted, preempted at any time
•Achieved by either:
• OS rapidly switching threads/p-rocesses
• Two threads/processes executing simultaneously
•Concurrency via Context Switching

Parallel

•Parallel (simultaneous)
• Actually at the same time (same cycle)
• Parallelism is concurrency
• Usually results in performance gains
•Concurrency is not (necessarily) parallelism

Multi-Threading

•Multithreading does not (neces-sarily) mean parallel
• But it does mean concurrent
•The issues that arise with multithreaded programming are due to concurrency, not parall-elism

SMT

•Simultaneous multithreading
•The ability of a core to execute multiple threads simultaneously
•Intel calls it “hyperthreading”
• (a little more to it than this)

Lec 14 (cont)

C# Form

•How does a C# Form control program flow?

```
static void Main()
{
...
Application.Run(new Form1());
}
public Form1()
{
InitializeComponent();
}
```

Message Loop

•A Form is an “application message loop”
•System creates a new thread to run the loop
•Thread essentially runs this code:

```
while(m = NextMessage())
{
HandleMessage(m);
}
```

•Messages are placed in to the thread’s “queue” by the OS
•When the mouse is moved
•When the mouse is clicked
•When a key is pressed
•When a window is resized
•etc…
•Most of the time, handling the message is just invoking event handlers

Handeling Messages

```
while(m = NextMessage())
{
HandleMessage(m);
}
```

•If handling the message is expensive, then other messages get stalled
•GUI becomes unresponsive

Lec 15

Modals(Pop-Ups)

```
async void doit() { //async bool
DisplayAlert( … )
overwrite = await DisplayAlert(
"Warning", // Title
"Spreadsheet changed, do you want to continue?", // Message
"Yes", // True choice
"No" ); // False Choice
```

Partials

```
// file: YourCode.cs
class MainPage XML → MauiCode.cs
{ partial class MainPage
…
}
```

Good Software Practices lead to

Better Architecture ☐ FDMM
MVC, Client Server, Event Driven
Use of “tried and tested” libraries
SOLID → FDMM
Smaller “units” (multiple single responsibility functions)
Documentation ☐ FDMM
Versioning ☐ FDMM
Testing ☐ FDMM
Design Patterns → FDMM
FDMM – Fewer Defects, More Maintainable

Lec 15 (cont)

Open/Closed Example

Modifying the code in _working_ software can lead to defects
New software needs more functionality.
Avenues of “Openness”
Extend
Inherit
Open for extension/Closed for modification

Code Alignment

Makes code:
Easier to Read
Easier to spot “one offs” or “copy paste” mistakes

```
float thousands = 1000;
float millions = 1000000;
float billions = 100000000;
```

Even Better: Use number underscores

Threads vs. Tasks

You may read about/hear about “Tasks”
Both allow processes to run in parallel.
Task is a higher level abstra-ction with additional functionality:
Can return a result
Can be cancelled
Can use Async and Await keywords*
Can use the “Thread Pool”
For our current purposes, there is little difference.

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Lec 15 (cont)

Shared Data is Problematic

Parallelism
When possible do work on separate data
When NOT use locking
We'll talk more about this later
Slows down the process

Key Methods

Constructor:
worker1 = new Thread(() => function());
Start – actually begin the work
worker1.Start()
Join – wait for that work to be done
worker1.Join()

Parallel Vocab

Thread
A separate unit of execution (assigned a method/function)
Race Condition
Two (or more) threads have access to same data at the same time
Lock
Protects a critical region of code (which almost always should contain a shared resource, e.g., a common variable/data structure)
Deadlock
Two+ threads are waiting for each other in order to continue

Lec 15 (cont)

Deadlock Example

Note: You won't get Deadlock in Spreadsheet GUI
Need at least two locks
Only shared resource might be GUI widgets (e.g., buttons)
Should "turn these off" when doing a long computation
Protected by Backgroundworker Semantics and/or Invoke

Characteristics of GSP

Defects (bugs) Reduction
Testing, Architecture, SOLID
Maintainability
Understandable/Readable
Testing ☐ Regression resistant

Lec 16

Software Practice - Problem Solving(Coding)

Problem: I want to choose where to save a file (spreadsheet) in my MAUI application
Solution:
Software Practice in practice
Step 1: Google - choose good keywords
Step 2: Stackoverflow - verify it "looks legit"
Step 3: Nuget and Troubleshoot

Lec 16 (cont)

Networks

We will cover the introductory concepts about program to program communication over a network
For a deeper understanding, take CS 4480 - Networking

Two way Communication

Address and recipient
Address and sender

Identification Information

Real World (i.e., Apartment)
Address (# street state zip), Mailbox/Apartment (#)
Computer
URL: e.g., www.cs.utah.edu (human readable)
Really IP Address: e.g., 155.98.65.24 (machine readable)
Port: e.g., 80

Architecture: Client ⇔ Server

Client wants to do some "work"/"play"
Server controls functionality
Client usually shows the GUI
Server usually manages the Model/Data

Lec 16 (cont)

DNS -Domain Name System

How do you know "where" Jess lives?
Need an Address?
Could ask operator ☐
"Where is the Jess' House?"
I suppose you could ask Google…
How do you know "where" cs.utah.edu lives?
DNS ☐ Domain Name System
Provides "IP Address"
Need a computer address:
Where is:
cs.utah.edu
Aside: how do you know where DNS lives?
Google DNS:
Configure your network settings to use the IP addresses 8.8.8.8 and 8.8.4.4 as your DNS servers.
If you decide to try Google Public DNS, your client programs will perform all DNS lookups using Google Public DNS.

IP Version 6 and local nets: Too many computers…

Note IPv4 vs. IPv6 (number of addresses)
Think license plates in Utah vs. California
Local network: 192.0.0.1
Most of your home routers

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Lec 16 (cont)

Ports -"MAIL BOXES" ASSOCIATED WITH SPECIFIC PROGRAMS

Once at the "building", distribute to the recipient

Client ⇔ Server Communications

Needs:
The address of the server machine
Initial port to talk to
A unique port for future communication
The Protocol(s)!

Can you have multiple Clients ⇔ with a single Server?

see stackoverflow?

Initial Port vs. Continuing Port

For Query/Response programs (e.g., a web server):
the server will use a specific low port that is "known" so anyone can make an initial connection
i.e., 80
Ongoing connections will be moved to a different (high) port number
So that new clients can talk to server at the same time

Lec 16 (cont)

Ports -1

"Mailbox Numbers" for the computer
Unique to for each program
If you try to "open" a port that is already in use you will get an error
Note: this could happen if you try to run/debug two versions of the same program at the same time
Numbers
Range: 0 - 64k
taken over -> used so much they have become defaults…

Ports -2

Who decides number?
Some programs have official ports
Other programs have "taken" over ports
Some ports screened/blocked by firewalls!
Especially low ports under 1000

Sockets -OPENING CONNECTIONS BETWEEN CLIENTS AND SERVER

Socket ☐ Unique Channel between Sender and Receiver
Client asks the Server for connection.
A Socket is defined!

Lec 16 (cont)

Socket

An identifier representing a particular point to point communication connection between two pieces of software
My IP ADDRESS
Their IP ADDRESS
My Port Number
Their Port Number
Combined into a single unique communication channel

Network Protocols

Agreed order and format of data for communication
What protocols do we have in this classroom?
Hand raise ☐ Professor Calls Upon ☐ Acknowledged person answers
Professor says Answer Clicker Question ☐ Students input data

XML Commenting Protocols

How do we define comments about parameters?
<param name="abc"> info </p-aram>

IP -Internet Protocol

Responsible for sending packets of information from host to host
Hand-wave Hand-wave Hand-wave
(or Abstraction/Separation of concerns)
The internet and C#'s usage of it just works!

Lec 16 (cont)

TCP -Transmission Control Protocol

Runs on top of IP (Internet Protocol)
One to One Reliable Communication
Data will arrive
Verified Ordering
Verified Uncorrupted
Does not verify when data arrives or how much arrives at a given time!
C# libraries do all the work for you
Take the Networking course! CS 4480

UDP -User Datagram Protocol

Alternative to TCP
No Handshaking – no persistent connection
No guarantee of
Delivery
Ordering
Duplication Protection
Why would we use this?
Faster – less overhead

Basic Network Communication Facts:

Happen at the BYTE level!!!!
Your program must
Translate useful data into bytes and
Translate bytes into useful data (e.g., strings, objects, etc)
TCP does not guarantee
When Information Goes Out
When Information Arrives
How much information is sent at any one time…
TCP does guarantee
order and validity

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Lec 16 (cont)

Stacking Protocols

Web browsing looks something like this

HTTP

TCP

IP

Need our own Protocol

If you can't guarantee when or how much data the program receives, how do you know when you have a full message:

jim is great… ☺

…ly overrated ☹

Answer: define a protocol

For example: the character '.' will mean we are done:

jim is great.

Problems?

Other Suggestions?

How about writing the number of characters as the first byte?

Communication Example

Question:

Have you written a Program to Communicate with another Program?

Answer:

The Spreadsheet communicates with "another program" (itself) via saving data

What the server's connection thread does

A SERVER DOES TWO THINGS:

"NETWORK STUFF" (E.G., HANDLE MULTIPLE CLIENT REQUESTS AND CONNECTIONS)

"APPLICATION STUFF" (E.G., MANAGES A GAME)

Lec 16 (cont)

TCP Handling in C#

A TCPListener object is at the heart of the server.

Listens on a specific port for incoming connection requests.

TcpListener

BeginAcceptSocket – Wait for request to arrive

EndAcceptSocket - Obtains the Socket.

Lec 17

GSP Overview

GSPs refer to tools, techniques, processes, etc., that are used to ensure our code is:

Easier to maintain

Contains fewer defects

Examples include:

Versioning (git/github/github projects)

Design Patterns

System Architecture decisions (e.g., MVC)

SOLID, DRY

Diagramming/UML

Testing

Unit Testing, Integration Testing, open/closed-box testing, C# test syntax, e.g., TestClass()]…)

Lec 17 (cont)

Chat Client Examples

Some Key Issues:

What is a stringbuilder (as opposed to a string)? {nl}}Why do we use it?

What is a byte[] (as opposed to a string)?

Why do we use it?

What are character encodings (UTF8)?

Can we convert between these?

More Key Issues

Watch for Race Conditions in your code

What values can multiple threads access?

E.g., Client array

Removing items from a shared list

Network Realities

How much data comes at once?

Protocols: "what is a message?"

127.0.0.1 (localhost)

Simple Chat Client/Server Key Methods

Key Methods

BeginAcceptSocket

Wait for someone to talk to you

BeginConnect

(Ask to) Start talking to someone else

BeginSend, EndSend

Send data

BeginReceive, EndReceive

Receive data

Simple Chat Client/Server Key Concepts

Key Concepts

"Event" callbacks

Older vs. Newer

Await Async

Lec 17 (cont)

Continued Key Issues

How do you convert from an "object type" to an "actual" Type?

Why is IAsyncResult.AsyncState not typed….

What is meant by an Event (Receive Event) loop?

New Version of Code

Async - tells the system that the code may "pause" and "return" later

Allows other threads to execute

Await - tells the system to "wait" here (pause thread) until an "event" happens

Let's look at the tcpclient version of the code.

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