Introduction

Why (GIS) Programming?

• Streamline routine/repetitive procedures
• Implement new algorithms
• Customize user applications
• ...

Computer Software Architecture

<table>
<thead>
<tr>
<th>Application macros and scripting</th>
<th>Software Development Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>- AML, Avenue, Python</td>
<td>- VB, .NET, C++, Java</td>
</tr>
<tr>
<td>- Visual Basic for Applications (VBA)</td>
<td>- Compilers</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Software Applications (AP)</th>
<th>Operating System (OS) – e.g., Windows XP / UNIX</th>
</tr>
</thead>
<tbody>
<tr>
<td>– ArcMap, Word, Excel</td>
<td></td>
</tr>
<tr>
<td>- Binary executables (.exe)</td>
<td></td>
</tr>
</tbody>
</table>

| Central Processing Unit (CPU) |                                                  |

Different Types of Computer Programming Tools

- **Compiler**
  - Source code -> object code
  - CPU “reads” object code and executes instructions

- **Interpreter**
  - Scripts, macro programming language
  - Applications (e.g., MS Word) “read” scripts and executes instructions
  - VBA
ArcGIS Programming

- Compiler approach
  - Java, C++, .NET, VB compiler
  - GIS code libraries: ArcGIS Engine, ArcObjects
  - Interact through COM (Component Object Model) components (e.g., ActiveX DLL)
    - Stand-alone EXE
- Interpreter approach
  - ArcMap and ArcCatalog
  - GIS code libraries: ArcObjects
  - Interact through VBA
  - VBA macro (scripts)
Software Engineering and Design
Software Design & Programming

• Requirement analysis
• Structured systems analysis
• Data specification
• Program specification
• GUI

Components of Computer Programming

• Programming language
• Algorithm
• Editor
• Code libraries and resources (.lib & .obj)
• Compiler/Interpreter
• Debugger
• Packaging/Deployment tools

Integrated development environment (IDE)
What are the differences between Visual Basic, VBA, and VBScript? When would I use one over another?

• Visual Basic is a stand-alone tool for creating separate software components, such as executable programs, COM components and ActiveX Controls, and is useful when you must build a specialized solution from scratch.

• VBA offers the same powerful tools as Visual Basic in the context of an existing application, and is the best option for customizing software that already meets most of your needs.

• VBScript is a lightweight version of the Visual Basic language, and is designed specifically for use on Web pages. While scripting can sometimes be used for simple automation, VBA is the premier technology designed specifically for application automation. Unlike VBA, VBScript does not have an integrated development environment (IDE).
Computer Language Components

- Syntax
  - Subroutine, procedures, functions (intrinsic and external)
  - Expressions and statements
  - Keywords
  - Naming convention
- Variables / constants
  - Data types
  - Declaration
  - Assignment and retrieval
- Operands / operators
  - Arithmetic, logical, assignment, bitwise, …
- Scope
- Exception / error handling
- Visual components
  - IDE, GUI Objects

VB Statements

a = 3
b = 2 + 5
c = a + b
d = d + 1
aValue = 1 + 6 / 3 * 2 ^ (1 + 1)
bValue = a + b / c * d ^ 2
If a > b Then c = 3
Procedures/Subroutines/Functions

Private Sub MyFirstControl_Click()
    ‘VB Codes
    ‘...
End Sub

Example

Sub Hello_World()
    Dim a As Integer
    Dim i As Integer
    a = 3
    For i = 1 To a
        Debug.Print “Hello World!”
        Next
End Sub
VBA Data Types

<table>
<thead>
<tr>
<th>Data type</th>
<th>Storage size</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boolean</td>
<td>2 bytes</td>
<td>True or False</td>
</tr>
<tr>
<td>Byte</td>
<td>1 byte</td>
<td>0 to 255</td>
</tr>
<tr>
<td>Integer</td>
<td>2 bytes</td>
<td>-32,768 to 32,767</td>
</tr>
<tr>
<td>Long</td>
<td>4 bytes</td>
<td>-2,147,483,648 to 2,147,483,647</td>
</tr>
<tr>
<td>Currency</td>
<td>4 bytes</td>
<td>-922,337,203,685,477.5808 to 922,337,203,685,477.5807</td>
</tr>
<tr>
<td>Single</td>
<td>4 bytes</td>
<td>-3.402823E38 to 1.401298E-45 for negative values; 1.401298E-45 to 3.402823E38 for positive values</td>
</tr>
<tr>
<td>Double</td>
<td>8 bytes</td>
<td>-1.79769313486231E308 to 1.79769313486231E308</td>
</tr>
<tr>
<td>String (variable-length)</td>
<td>10 bytes + string length</td>
<td>0 to approximately 2 billion String</td>
</tr>
<tr>
<td>String (fixed-length)</td>
<td>Length of string</td>
<td>1 to approximately 65,400</td>
</tr>
<tr>
<td>Currency</td>
<td>8 bytes</td>
<td>-922,337,203,685,477.5808 to 922,337,203,685,477.5807</td>
</tr>
<tr>
<td>Object</td>
<td>4 bytes</td>
<td>Any Object reference</td>
</tr>
<tr>
<td>Variant</td>
<td>16 bytes</td>
<td>to variant length</td>
</tr>
</tbody>
</table>

- Dim X As Boolean
- Dim X As String, Dim Y(10) As String
- If you do not specify a data type, the Variant data type is assigned by default, i.e., Dim X.

VB Variables
Naming Convention

Examples:

Global Const cdMyPI = 3.14159
Dim bSelected As Boolean
Public giMapNo As Integer
Object-Oriented Programming (OOP)

- Object
  - Events (response to triggers)
  - Properties
  - Methods

- Class (a collections of similar objects)
  - Events
  - Properties
  - Methods

- Interface (for accessing properties and methods of objects)

Object Model

1. Orchard is a type of farm (there are many other types of farm). - association
2. An orchard has trees. - composition
3. A tree has branches. - composition
4. A branch can grow fruit. - instantiation
5. A branch can grow leaves. - instantiation
6. An apple tree is a tree. - type inheritance
VB Control Naming Convention

<table>
<thead>
<tr>
<th>Object</th>
<th>Prefix</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form</td>
<td>frm</td>
<td>frmSelect</td>
</tr>
<tr>
<td>Label</td>
<td>lbl</td>
<td>SearchString</td>
</tr>
<tr>
<td>Combo box</td>
<td>cbo</td>
<td>cboEditFeature</td>
</tr>
<tr>
<td>Command button</td>
<td>cmd</td>
<td>cmdCancel</td>
</tr>
<tr>
<td>Directory listbox</td>
<td>dir</td>
<td>dirPath</td>
</tr>
<tr>
<td>Drive listbox</td>
<td>drv</td>
<td>drvDrive</td>
</tr>
<tr>
<td>Image</td>
<td>img</td>
<td>imgBitmap</td>
</tr>
<tr>
<td>Listbox</td>
<td>lst</td>
<td>lstSelectedFile</td>
</tr>
<tr>
<td>Menu</td>
<td>mnu</td>
<td>mnuFileSaveAs</td>
</tr>
<tr>
<td>Option button</td>
<td>opt</td>
<td>optTopology</td>
</tr>
<tr>
<td>Timer</td>
<td>tmr</td>
<td>tmrAlarm</td>
</tr>
<tr>
<td>Common dialog</td>
<td>dlg</td>
<td>dlgSaveAs</td>
</tr>
</tbody>
</table>
How to save your programs in ArcGIS?

- ArcGIS Normal template (Normal.mxt)
- A base template (*.mxt)
- A map document (*.mxd)

Where to Find Help?

- **VB**
  - VBA Online Help (F1 on the VBA IDE)
  - .Net2TheMax
  - MicroSoft Developer Network (MSDN)
  - Windows API Reference
- **ArcObjects**
  - ArcGIS Desktop Help for VB6/VBA Developers
  - ArcScripts
  - ESRI Developer Network (EDN)
  - ESRI ArcObjects Library Reference