Study on Object-Oriented Language Eiffel

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Introduction

- History

Bertrand Meyer

Eiffel Power™

from ISE

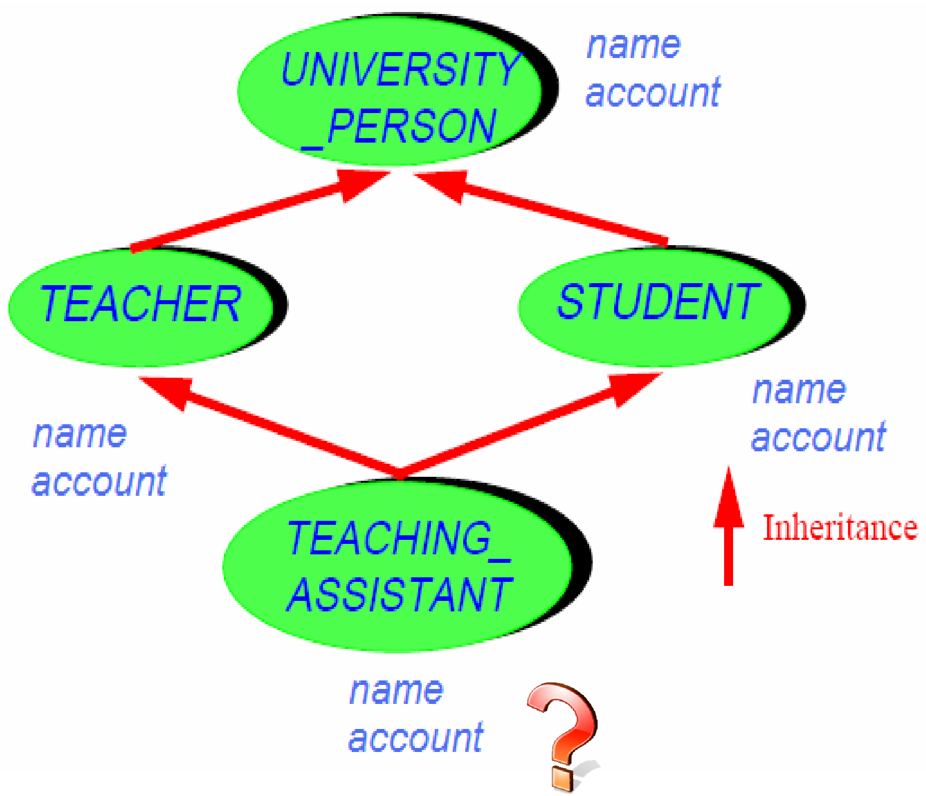
Case Study

```
deferred class
      VEHICLE
feature entities
      velocity:INTEGER is --a function
            do
               Result := speed
            end
      wheels: INTEGER is
            deffered
            end
      speed: INTEGER
      stop is --a procedure
            deferred
            end
end--VEHICLE
```

```
class
      CAR
inherit
      VEHICLE
feature entities
      color: COLOR --a field
      wheels: INTEGER is 10 --a constant
      speed: INTEGER
      stop is -- a procedure
            speed := 0
            end
end--CAR
```

Special Properties

- Multiple inheritance and Renaming




```
class TEACHING_ASSISTANT inherit
        TEACHER
            rename
                account as faculty_account
            select
                faculty_account
            end
        STUDENT
            rename
                account as student_account
            end
```

ta: TEACHING_ASSISTANT

up: UNIVERSITY_PERSON

up := ta

ta.faculty_account ✓

ta.student_account ✓

ta.account ✗

up.account → ta.faculty_account

Special Properties

- Typing (Static)
  - Genericity
    - Unconstrained
      - STACK[G]
    - constrained
      - BINARY_TREE[G->COMPARABLE]
  - Assignment attempt
      - X ?= Y
  - Anchored declarations
      - X: like Y
  - No type cast

Special Properties

- Exception Handling

```
write_next_character(f:FILE) is
        --Write the available in last_character in to the file
        --retry 5 times
    require
        writeable:file.writeable
    local
        num_attempts:INTEGER
    do
        low_level_write_function(f,last_character)
    rescue
        num_attempts:=num_attempts+1
        if num_attempts< 5 then
            retry
        end
    end
```

- No Main and Globals
  - Root class
  - Root procedure

Design Principles

- Design by Contract

provide_service	**OBLIGATIONS**	**BENEFITS**
Client	(Satisfy precondition:) Pay bill	(From postcondition:) Get telephone service
Supplier	(Satisfy postcondition:) Provide telephone service	(From precondition:) No need to provide anything if bill not paid

- Command Query Separation
- Uniform Access Principle
  - a.balance (attribute? function?)

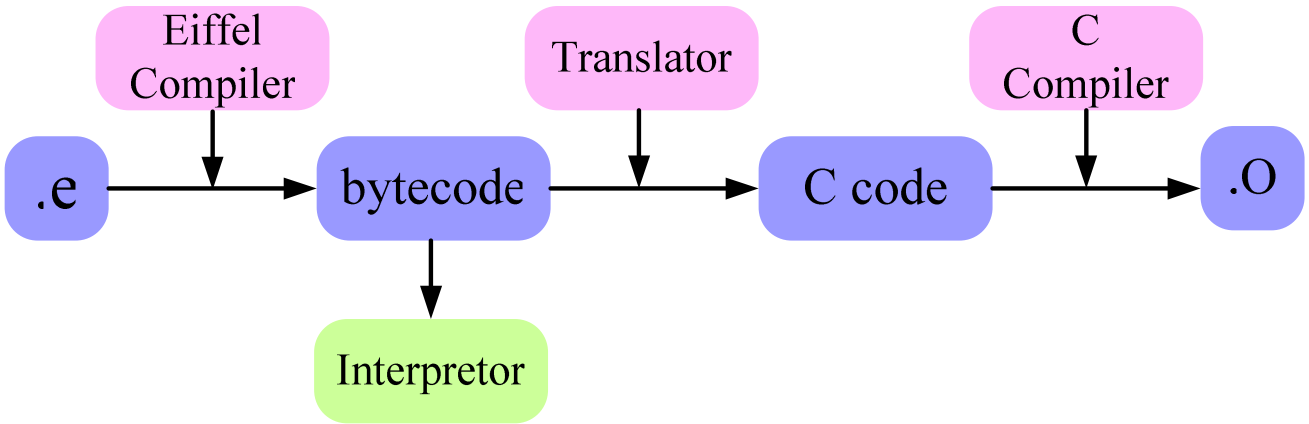
```
class ACCOUNT
feature – Access
    balance : INTEGER –Current balance
    deposit_count : INTEGER is–Number of deposits
        do
            if all_deposits /= VOID then Result:= all_deposit.count end
        end
feature – Element change
    deposit(sum:INTEGER) is – Add sum to account
        require non_negative: sum >= 0
        do
            if all_deposits = VOID then create all_deposits end
            all_deposits.extend(sum)
            balance:=balance+sum
        ensure
            one_more_deposit: deposit_count= old deposit_count+1
            updated: balance= old balance+sum
        end
feature{NONE} – Implementation
    all_deposits: DEPOSIT_LIST –List of deposits
invariant
    consistent_balance : (all_deposits /= Void) implies (balance=all_deposits.total)
    zero_if_no_deposits : (all_deposits = Void) implies (balance=0)
end–class ACCOUNT
```

Query

Command

Internals

- Compilation process



- Garbage Collection
  - Mark and Sweep
  - Generation Scavenging

OO languages Comparison

Factor	Eiffel	C++	Java
How object-oriented	Purely OO	Hybrid	Purely OO
Design by Contract and assertion	Design by Contract Language support	Nothing comparable Only assert instr	Nothing comparable Only assert instr
Static typing	Statically typed	Statically typed but C style cast allowed	Typed mostly statically but dynamic for containers
Compiler Technology	Combination of interpretation and compilation	Usually compiled	Mix of interpretation and on the fly compilation
Automatic Documentation	Documentation extractd automatically without extra programmer effort	No standard mechanism	JavaDoc: add special comments
Multiple Inheritance	Multiple inheritance	Multiple inheritance but with problems	Single inheritance but multiple interface
Automatic memory management	Garbage collection automatic memory management	No Garbage collection	Garbage collection

Summary

... All that you need,
To program with speed:
Objects and classes,
Compiled in four passes...
Try inheritance today,
In the Eiffel way,
And you are certain to find,
That when it is combined,

With the bindings dynamic,
And the typings static,
And the classes generic,
And ISE magic,
Things fall in place,
By mysterious grace,
Makes programming a pleasure,
By any sane measure...

-- Ross D'Souza, 1992

Objective-C

Introduction

[Karthik Ravichandra]
[Bhavin Mankad]

History

1984

- Designed by Brad Cox and Tom Love at their company StepStone

1988

- Steve Jobs' NeXT licensed Objective C from StepStone and released their own version of Objective-C compiler, libraries (NeXTstep)

1992

- NeXT partnered with Sun Microsystems to develop OpenStep based on NeXTstep
- GNUstep - Glatting, Stallman

1996

- Apple acquired NeXT and used OpenStep in Mac OS-X

* Timeline not to scale

Goals of Design

- Object Oriented Design and Development
- Strict Super-set of C
- Simple Syntax Extensions to C, influenced by SmallTalk
- Convenient Mixing of Structured and Object Oriented Programming
- Dynamic Behavior

Sample Code

- Square.h - Interface

```
#import “Shape.h”

@interface Square: Shape {
   float side;
}

+ (void) countRectangles;
- (id ) initWithSide: (float) side;
@end;
```

- Square.m - Implementation

```
#import “Square.h”

@Implementation Square

-(void) initWithSide: (float) side
{
   //method body
}
@end
```

Objects, Classes and Inheritance

- Basic Building Blocks of OO programming
- Only Single Inheritance allowed
- NSObject is the root for all classes
- Dynamic or Static Typing for Objects

```
id square =[ [Square alloc] init];
                    or
Square *square = [[Square alloc] init];
```

Messaging

- Syntax:

→ **Message without arguments**

[rectangle init];

→ **Message with two arguments**

[rectangle setLength:100 andWIdth:60];

- Method calls via message passing
- Preprocessor translates a message into objc_msgSend(..) function
- Class template lookup for method calls on objects at runtime (Similar to Luca!)

Dynamic Behavior

- Dynamic Typing
  - Deciding the class of an object at runtime.
- Dynamic Binding
  - Deciding which method to invoke at runtime.

id Obj = getReceiverObj(bool flag); // True – Rectangle, False – Square

SEL msg = getMessage(bool flag); // True – SetWidth, False - Setsize

[Obj performSelector: msg];

Categories

- Extends the functionality of a class.
- A good alternative to sub-classing.
- Sub-classes inherit the new methods.
- Merits
  - Can split implementation of a huge class.
  - Simplifies code management.
  - Base class code is not recompiled.

Properties.

- Allows for easier ways to access variables.
- Can associate attributes.
  - readwrite, readonly etc.
- Can synthesize getter and setter methods.

```
@interface Rectange{
   …
   @property (readwrite) int size;
   …
}
```

```
@implementation Rectangle{
    …
    @synthesize size;
    …
}
```

```
Rectangle *rect = [[Rectangle alloc] int];
rect.size = 10;   // [Rectangle setSize: 10]
```

Memory Management

- Manual Memory Management in 1.0
- Uses reference counting technique.
- Keywords - retain, release, autorelease.
- Example:

```
Rectange *rect = [[Rectangle alloc] init]; // retainCount is 1.
Rectangle *tmprect = rect;                 // Another reference to rect.

[tmprect retain];                          // So we increment the retainCount.
….
[tmprect release];                         // Decrement retainCount.
….
[rect release];
```

Summary

- One of the early Object Oriented Languages.
- Popularized by Apple.
- Based on C, influenced by Smalltalk.
- Significant Dynamic Behavior.
- Some cool features like Categories, Properties etc.
- Generation based Garbage Collection.

MODULA-3

Swaminathan Sankararaman   Bojan Durickovic

MODULA-3 Example

LinkedList.i3:

```
INTERFACE LinkedList;

PROCEDURE Add(VAR I : INTEGER);

END LinkedList.
```

Imports

Main.m3:

```
MODULE Main;
IMPORTS LinkedList

VAR n : INTEGER;

BEGIN
    n := 3;
    LinkedList.Add(n);
END Main.
```

Exports

LinkedList.m3

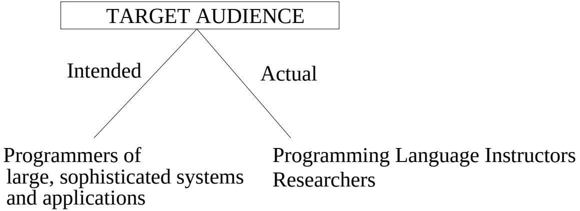
```
MODULE LinkedList;

PROCEDURE Add(VAR I : INTEGER) =
    .
    .
    .

BEGIN
END LinkedList.
```

History

Year	Event
1986	Proposal
1988-1989	Language Definition
1990s	DEC SRC-M3, CM3 and PM3 released
1990s	Popular as a teaching language
1994	SPIN OS developed
1996-1997	CVSup developed
2000	Critical Mass Inc. ceases operations
2000-2002	Elegosoft takes over CM3 and PM3

Goals and Target Audience

- Structuring of Large Programs
- Safety and Robustness
- Machine-level programming
- Simplicity



Objects and Generics

OBJECT

- Record paired with Method Suite

```
TYPE T = OBJECT
        a: INTEGER;
       METHODS
        a() := A
END;
PROCEDURE A(self: T) = ... ;
```

GENERICS

- Parametric Polymorphism
- Entire Modules and Interfaces are Generic

```
GENERIC INTERFACE LinkedList(Elem); TYPE T <: REFANY;

GENERIC MODULE LinkedList(Elem);
        REVEAL T = BRANDED OBJECT val: Elem.T  ;
        METHODS set(v: Elem.T) := P; END;
        PROCEDURE P(self:T; v:Elem.T) = ... ;
END m1.

INTERFACE Integer; TYPE T = INTEGER END Integer.
INTERFACE IntList  = LinkedList(Integer) END IntList.
MODULE IntList = LinkedList(Integer) END IntList.
```

Type System

NO Ambiguous Types or Target-Typing	`VAR x:REAL; y:INTEGER; z:REAL;`
	`x := y*z;`
	`(* Type of y*z depends on y and z and not x *)`

NO Auto-Conversions	`VAR x:REAL; y:INTEGER;`
	`y := x;`
	`(* No Automatic floor(). Static Error *)`

Type Compatibility	$S <: T \implies S \subseteq T$
Structural Equivalence	$T \equiv U \implies$ Expanded Definitions of T and U are the same
Procedures	Global→First-Class,Local→Second-Class

Information Hiding - Revelations

- At an implementation level, reveal only features of the type relevant to that level

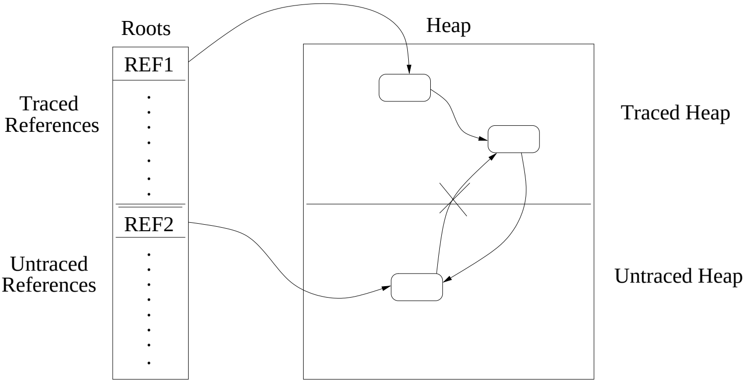
  REVEAL T <: U

- Revelations are linearly ordered with final revelation defining the concrete type of the object

1st	INTERFACE LinkedList; REVEAL T <: LL	Implementor knows only details of Linked List
2nd	INTERFACE LinkedListChar; REVEAL T <: LLChar	Implementor knows only details of Char Linked List Also LLChar <: LL
3rd	INTERFACE String REVEAL T = STR	Implementor knows details of String

Safety and Garbage Collection - I

- Traced/Heap and Untraced References/Heap



Safety and Garbage Collection - II

- Garbage Collection Algorithms in SRC Modula-3 Compiler
  - Mostly Copying Collection
  - Incremental, Generational
- SAFE AND UNSAFE MODULES

SAFE MODULES
No way to produce *unchecked runtime error*

```
VAR P: REF INTEGER
INC(P);
(* WRONG!! *)
```

UNSAFE MODULES
Type Transfers and Pointer Arithmetic allowed

```
LOOPHOLE(expr, Type)
VAR x, y: REF INTEGER;
y := ADR(x) + 1;
(* Allowed *)
```

Summary

- Large-Scale Systems and Applications
- Systems-Level programming when required and isolated when not
- Designers' goals realized through committee voting
- Not widespread in industry
  - Decline of DEC
  - Compiler Inefficiency
- Personal Experiences - Complex for small code but easy to modify and change implementation. Focus on design.

OBERON

Waj and Manish

Sample Program

```
MODULE Hello ;

IMPORT InOut ;

PROCEDURE Disp();
BEGIN
    InOut.WriteString(“HelloWorld”);
    InOut.WriteLn ;
END Disp ;

BEGIN
    Disp() ;
END Hello.
```

Introduction.

- Developed by Niklaus Wirth at ETH Zurich in 1986.
- Was originally designed for the Oberon Operating System.
- Simplified, reduced Modula-2.
- Is both Procedural and Object Oriented.
- Language specified in a page of EBNF.
- Oberon report is about 16 pages.

Procedures and Parameters

- Both pass by value and pass by reference supported.
- Open array parameter allowed.
  - PROCEDURE P(s: ARRAY OF CHAR)
- Procedure Forward Declarations
  - PROCEDURE ^Sum(x, y: REAL): REAL

Types

- Static type checking, Strongly typed
- Procedure type
  - Function = PROCEDURE():BOOLEAN ;

    search: PROCEDURE(f:Function; arr:ARRAY OF INTEGER) ;

    search(LinearSearch, in);

    search(BinarySearch, in);

Type Extension

- Ability to derive a new type from an existing one.
- Eg:

```
Base  = RECORD x, y: INTEGER END;
Extn  = RECORD (Base) z: INTEGER END;
```

- Extn is compatible with Base.
- This leads to classes and objects

OO Features

- Type Bound Procedures – methods and installation.
- Type Guard/Type casting.
- Polymorphism

```
TYPE Fptr = POINTER TO Figure ;
Figure = RECORD (* base type *)
    print  : PROCEDURE (f: Fptr) ;
END ;

Circle = RECORD(Figure)
   radius:Integer END;
Var c:Circle ;
NEW(c) ;
c.print := PrintCircle ;
```

Modules

- Basic building blocks.
- Definitions and implementation in the same file.
- Modules can be imported and exported.
- Facilitates data abstraction.

```
MODULE Hello ;
IMPORT InOut ;
PROCEDURE Disp();
BEGIN
  InOut.WriteString("HelloWorld");
  InOut.WriteLn ;
END Disp ;

BEGIN
  Disp() ;
END Hello.
```

MODULES Contd…

- Unit of execution is a procedure. Procedure in a module can be invoked as a command (eg: M.P where P is a procedure in M).
- Modules are dynamically loaded. Global data structures retain values and can be reused upon successive activations of the same procedure.

Dynamic Loading

- Modules are separate compilation units.
- No pre-linked files on the disk. Every module is compiled to a separate object file.
- Modules are loaded as and when commands are executed.
- Modules share the same address space and are loaded only once.

Other Features

- Garbage collection
- Fast Compilation.
- Generates native and portable code.
- Support for System Programming.
- Assertions.

Summary

- Simple Language
- 3 main features
  – Type extension
  – Abstraction
  – Dynamic Loading.
- No support for concurrency

C# Language

By Anand and Deepti

Hello World

```
using System;
using System.Collection;

namespace MySpace
{
    class Hello
    {
        static void Main() {

           Console.WriteLine("Hello world");

        }
    }
}
```

History

- Conceived by Microsoft in 1997
- Anders Hejlsberg leads development of C#
- Based on
  - C/C++
  - Java
- Emphasis on simplification

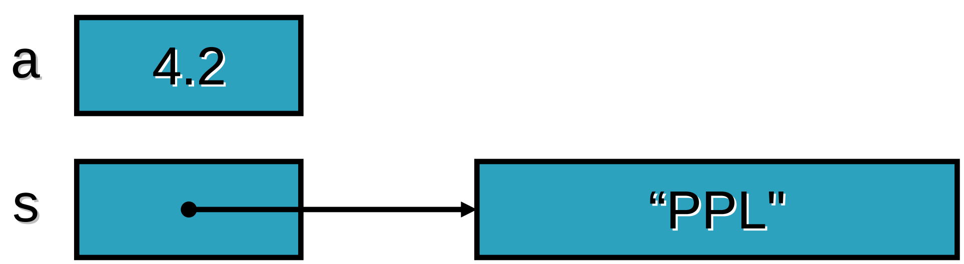
Target Audience

- Projects that require high productivity
  - Short learning curve
  - Massive base class library, like Java
- Windows Platform Developers
- Embedded Software
- Programming Models
  - Procedural Object Oriented

Type System

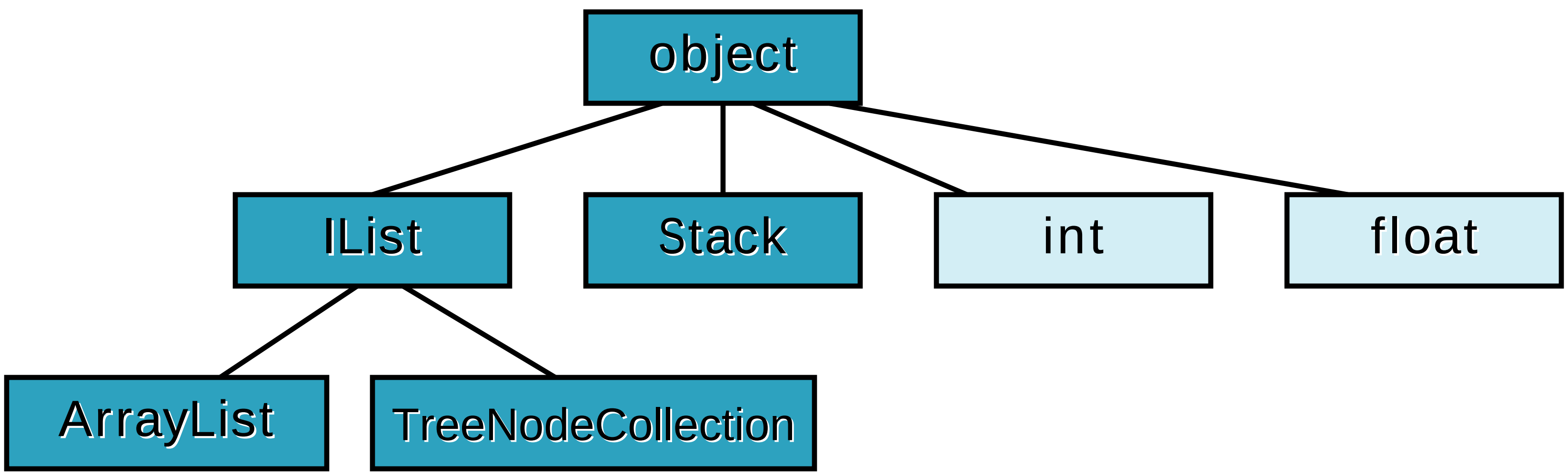
- Value types
  - Directly contain data
  - Cannot be null
- Reference types
  - May be null

```
float a = 4.2;
string s = "PPL";
```



Unified Type System

- Everything is an object
  - Primitive types are just an alias to the object type
- Type-safety
  - All variables are initialized



Unified Type System

- Boxing
  - Creates an object
- Unboxing
  - Copies the value out of the object

```
//Signature for hash table Add method
    Add(object key,object val)
//In C# code, you can write
    Hashtable h = new Hashtable();
    h.Add(5,"five");
```

Properties

- Used to 'set' and 'get' class members

```
public class MyClass
{
    private string myString;

    public string MyString {
        get {
            return myString;
        }
        set {
            myString = value;
        }
    }
}
```

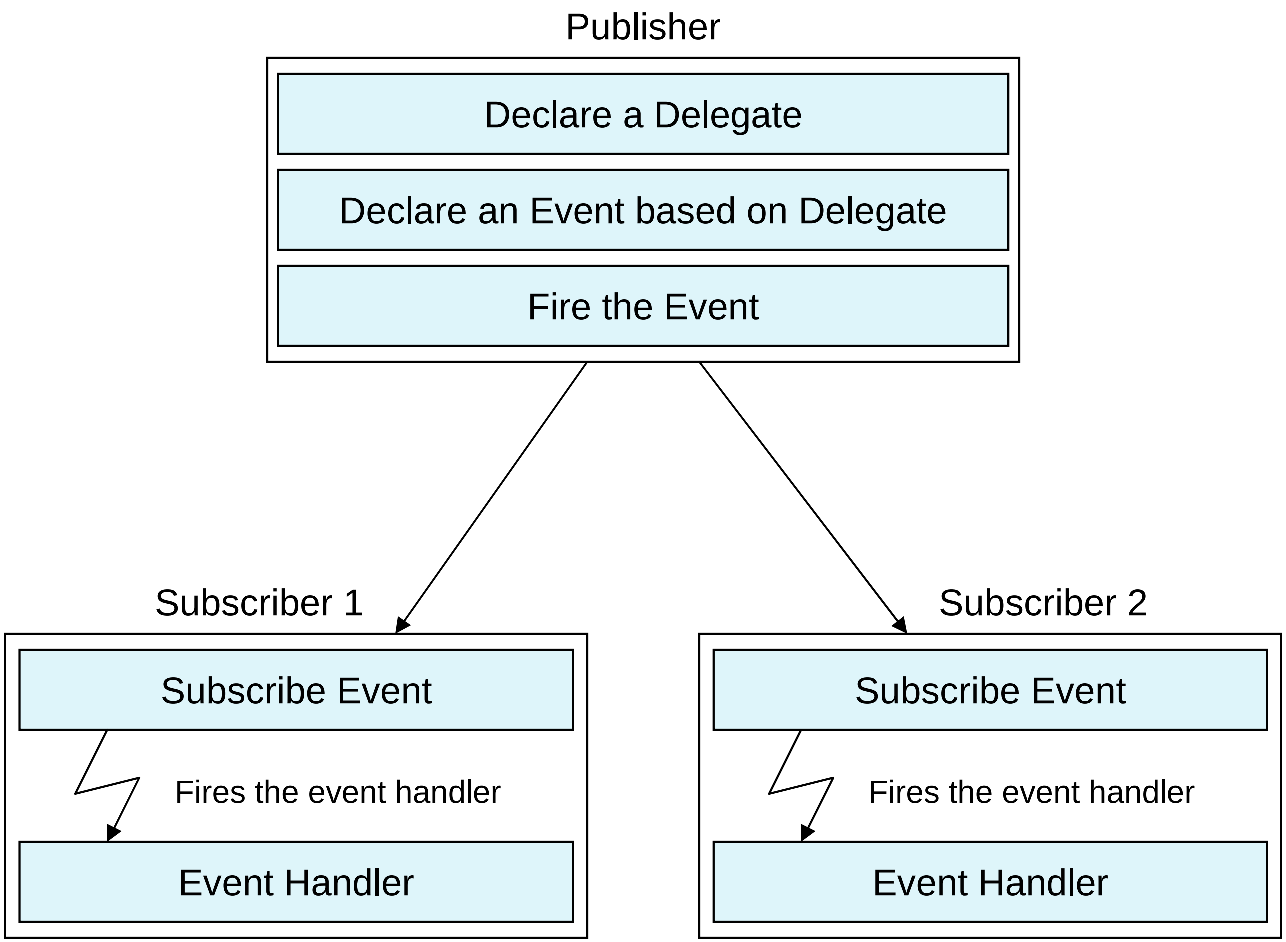
```
MyClass object = new MyClass();
object.MyString = “PPL";
String str = object.MyString;
```

Delegates

- Object oriented function pointers

```
public delegate void LogHandler(string message);      // Define the Delegate


public void ConsoleLog(string s){                     // Subscriber 1
    Console.WriteLine(s);
}

public void FileLog(string s){                        // Subscriber 2
    File.WriteLine(s);
}

LogHandler myLogger = null;                           // Declare the Delegate

myLogger += new LogHandler(ConsoleLog);               // Add to Subscription List
myLogger += new LogHandler(FileLog);

myLogger(message);                                    // Call Subscribers
```

Events


Publisher
Declare a Delegate
Declare an Event based on Delegate
Fire the Event
Subscriber 1
Subscribe Event
Fires the event handler
Event Handler
Subscriber 2
Subscribe Event
Fires the event handler
Event Handler

Events

```
public delegate void LogHandler(string message);     // Declare a delegate

public event LogHandler Log;                          // Declare an event based on the delegate

protected void OnLog(string message)                  // Fire the event
{
   if (Log != null)
      Log(message);
}

static void ConsoleLog(string message) {              // Event Handler
   Console.WriteLine(message);
}

Log += new LogHandler(ConsoleLog);                    // Subscribe to the Event Handler
```

Unsafe Code

- 'unsafe' keyword
  - Enables pointers of primitive type
  - Casts and pointer arithmetic
- 'fixed' keyword to escape the GC
- 'stackalloc' keyword to allocate from stack
  - Does not initialize, hence faster

```
unsafe
{
    int * ptr;
    ptr = &(new Int32(5));
    *ptr = 10;

    fixed (long *ptr_a = &(myClass.a))
}
```

Iterators

- Allows to iterate through members of your collection

```
public class MyList : IEnumerable<string>
{
    public IEnumerator<string> GetEnumerator()
    {
        foreach (string s in strings)
            yield return s;
    }
}

// Main program
foreach ( string s in mylist_object )
{
    Console.Write(s);
}
```

Garbage Collector

- Implicit GC
- Explicit GC
  - System.GC.Collect();
  - Run each unused object's finalizer on separate thread
  - System.GC.WaitForPendingFinalizers()

Summary

- Procedural Object Oriented
- Large Base Class Library
- Unified Type System
- Properties, Delegates and Events
- Unsafe code
- Iterators
- Garbage Collector
  - Implicit and Explicit

Forth
A Stack Programming Language

Harley Witt

Russell Lewis

Basic Syntax

1 2 +	1+2
5 DUP *	5*5
DUP 0 < IF -1 * THEN	(i < 0) ? -i : I

History of FORTH

- Charles (Chuck) H. Moore (1970)
  - Shorten Edit/Compile/Run Time
  - Text Interpreter To Act On Words
- National Radio Astronomy Observatory (Arizona)
  - Data Acquisition and Analysis
  - Radio Telescope Control

Our Example Program

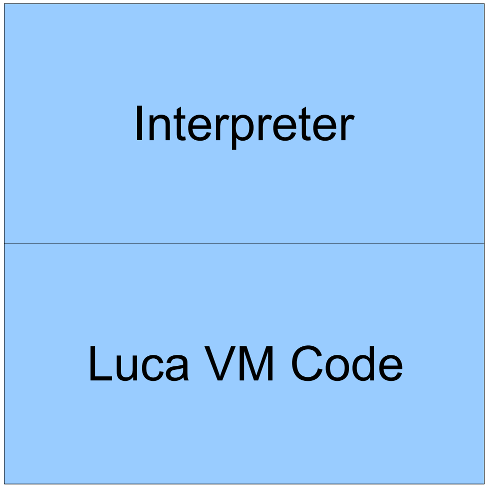
- Luca VM Interpreter
- Example word

```
: addi
    1 IGNORE_TOKEN
    +
;
```

- Luca VM code (filtered)

```
addi 0
```

Structure Of Interpreter



Executing Luca

```
pusha 0 15 0
pushi 0 37
storei 0
```

```
: pusha
 1 IGNORE
 NUMBER
 GETVARADDR
 1 IGNORE
;
```

Forth Stack Before:

(Empty)

Forth Stack After:

(0)

Executing Luca

```
pusha 0 15 0
pushi 0 37
storei 0
```

```
: pushi
 1 IGNORE
 NUMBER
;
```

Forth Stack Before:

(0)

Forth Stack After:

(0 37)

Executing Luca

pusha 0 15 0

pushi 0 37

storei 0

```
: storei
 1 IGNORE
 SWAP
 LUCATOFORTH
 !
;
```

Forth Stack Before:

(0 37)

Forth Stack After:

(Empty)

Strengths

- Bootloaders & prototype hardware
- “Portable assembly language”
- Extreme self-reflection and modification
- Integrated interpreter/compiler

Variables

VARIABLE foo	int foo;
VARIABLE bar 10 CELLS ALLOT	int[10] bar;
foo	&foo
foo @	“read” foo
1 foo !	foo = 1;
foo @ bar 3 CELLS + !	bar[3] = foo;
bar foo @ CELLS + @ bar foo @ 1- CELLS + !	bar[foo-1] = bar[foo];

Weaknesses

- Difficult syntax (parens are comments)
- Inconsistent syntax (some words are prefix)
- Terrible memory management
- Inadequate abstraction
- Not even trivial typechecking (think: like assembly language)

PostScript

Ravi Sheshu Nadella
Sushanth K. Reddy

Drawing a Square

```
/inch {72 mul} def          % Convert inches->points (1/72 inch)
newpath                     % Start a new path
1 inch 1 inch moveto        % an inch in from the lower left
1 inch 0 inch rlineto       % bottom side of the Square
0 inch 1 inch rlineto       % right side of the Square
-1 inch 0 inch rlineto      % top side of the Square
closepath                   % Automatically add left side to close path
stroke                      % Draw the box on the paper
1.2 inch 1.5 inch moveto
(PPL) show                  % print PPL inside box
showpage                    % Eject the page
```

University of Arizona, Department of Computer Science

CSc 520 — Assignment 1 — Due noon, Mon Feb 11 — 10%

Christian Collberg
January 28, 2008

1 Introduction

Your task is to write an interpreter for a small subset of the language LUCA. You will be given a front-end that performs lexing, parsing, semantic analysis, and intermediate code generation on LUCA source files. You will write an interpreter that reads in the code produced by the front-end, and then executes this code.

1. The interpreter should be implemented using *indirect threaded code*.
2. You should write your interpreter in C or C++ using gcc.
3. The interpreter should be named `lucax`. It should read the virtual machine code (in an S-expression format) from standard input.
4. You only have to implement control structures (`IF`, `WHILE`, etc.), integer and real arithmetic, a `WRITE` statement, and array indexing.
5. You should test the interpreter on lectura.
6. You should work in a team of two students.

PostScript

- 1976 - Basic concept conceived by John Warnock.
- 1984 - Warnock (founded Adobe) and released PostScript.
- 1985 - Language of choice for graphical output for printing applications.
- Once de facto standard for distribution of documents meant for publication

PostScript..

- Single control language could be used on any brand of printer.
- Implements rasterization - allows arbitrary scaling, rotating and other transformations
- Display postscript
- Device Independent – both printer and Screen

Language

- Interpreted – No intermediate Byte Code.
- Stack based execution.
- All data including Procedures exist as Objects (Simple and Complex)
- Objects – Type, Attributes and Value
- Dictionaries – systemdict, globaldict, userdict
- 300 built-in operators!

Data Types

- Static
- Integer, Real, Boolean, String, Array.
- Dictionary – associative table.
- String, Array and dictionary complex objects.
- Copy and Type Equivalence.

```
/exreal 20.5 def
/exstring (ravi) def
/exarray 10 array def
<<1 (LUCA) 2 (C#)>>
/ex2 exarray def
/ex3 exreal def
[ 1 2 3] [1 2 3] eq – false
```

Scope, Memory Management

- Scope enforced by dictionary, dictionary stack
- Values of Complex objects stored in VM.
- Local VM, Global VM
- Garbage collection

```
…………
/b{
   1 dict
   begin
         /d (PPL method) def
         d show
   end
   }def
…………
d show % d out of Scope - GC
```

Procedures

- Packed Arrays
- Executable Arrays
- Allows recursion
- Arguments passed via Stack
- Early Binding

```
/foo {add mul} bind def
```

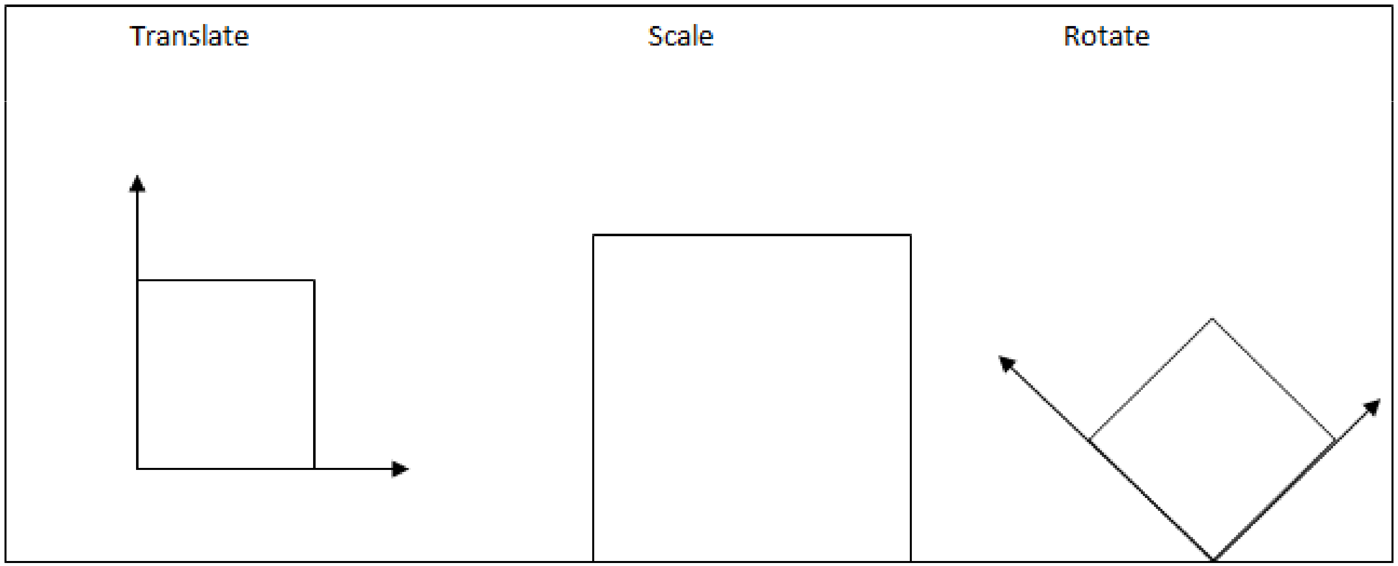
```
/factorial
{ dup 0 eq { 1 }
    {     dup
       1 sub
       factorial
      mul
    } ifelse
} def
```

Graphics

- Device Space - coordinate space understood by the printer hardware.
- User Space - coordinate system used by PostScript program.
- Current Transformation Matrix (CTM)
- Graphics State – current path, font, CTM
- Store and Restore from graphics stack

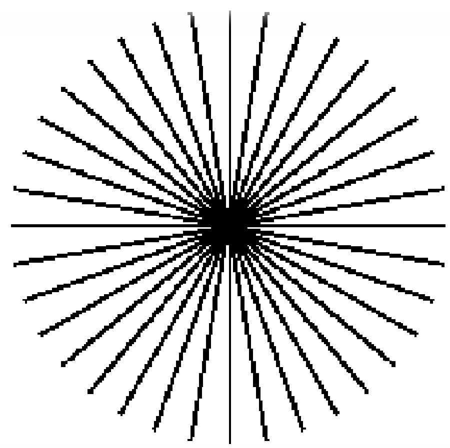
Graphics cont..

- Current transformation operators translate,rotate,scale
- Clipping Path – limit the region of the page to draw



Basic Graphics

```
0 10 360 {              % Go from 0 to 360 degrees in 10 degree steps
  newpath               % Start a new path

  gsave                 % Keep rotations temporary
    144 144 moveto
    rotate              % Rotate by degrees on stack from 'for'
    72 0 rlineto
    stroke
  grestore              % Get back the unrotated state

} for                   % Iterate over angles

showpage
```



Business card

If you want to know how this is done..
Read our report and cool program ☺

Summary

- Device independent
- Easy to code graphics programming languages
- Stack based interpreted language
- Many built in operators
- Flexible to add new operators, fonts.