Lecture 1: Introduction

COMP 514 Programming Language Concepts
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Based on slides and notes by A. Block, N. Fisher, F. Hernandez-Campos, and D. Stotts

Class Objectives.

- What are we going to do in this class?

Compare and **contrast** different programming languages.

- What does this entail?

Examine the way in which languages are **designed** and **implemented**.

Class Objectives.

- What are we going to do in this class?

Compare and **contrast** different programming languages.

- What does this entail?

Examine the way in which languages are **designed** and **implemented**.

Why do this?

1. For the **fun** of it!
2. Understanding the basic principles makes it **easier to learn new languages**.
3. Sometimes you need **different features of different languages**, and if you don't know about other languages how can you use them?
4. **More effectively utilize** the languages you already know.

Why do this?

1. For the **fun** of it!

2 **er to**

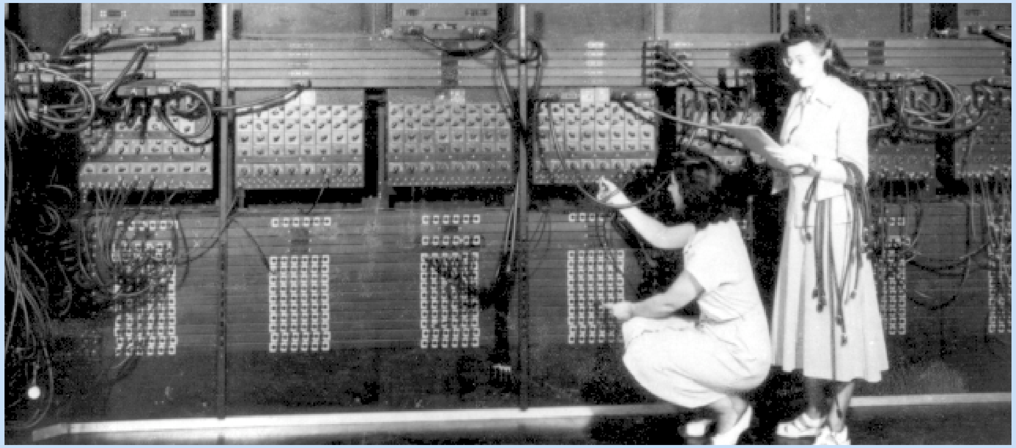
3 **ent**

For example, if you need **“fine-grained” control over system memory**, then you **C++** would be better choice than **Java**. However, if you memory leaks are a big concern, then **Java** is a better choice than **C++**.

4. **More effectively utilize** the languages you already know.

A very very very brief history of languages.

- In the beginning, ENIAC (Electronic Numerical Integrator and Computer) programers used **patch cords**.



- This gave them the raw power to compute trig tables.

Machine and Assembly Languages.

- The next major revolution was **machine language**, which is just binary (or hexadecimal).
- Very quickly people realized that humans cannot write error free programs using just zeroes and ones without going insane.
- Hence, came **assembly language**, which uses human readable abbreviations to stand for machine code.

Assembly language (example)

```
Start:   lea        A, a0
         lea        B, a1
         lea        C, a2
         clr.w      d0
         clr.w      d1
         clr.w      d2
         add.w      #5, d1
         add.w      #6, d2
         move.w     d1, (a0)
         move.w     d2, (a1)
         add.w      (a0), d0
         add.w      (a1), d0
         move.w     d0, (a2)
         jsr        decout
         jsr        newline
         jsr        stop

         data
A:       dc.w       1
B:       dc.w       1
C:       dc.w       1
```

Higher level languages

- Eventually, people realized that more complex programs are very difficult to write at the level of assembly language.
- So, eventually came higher level languages.

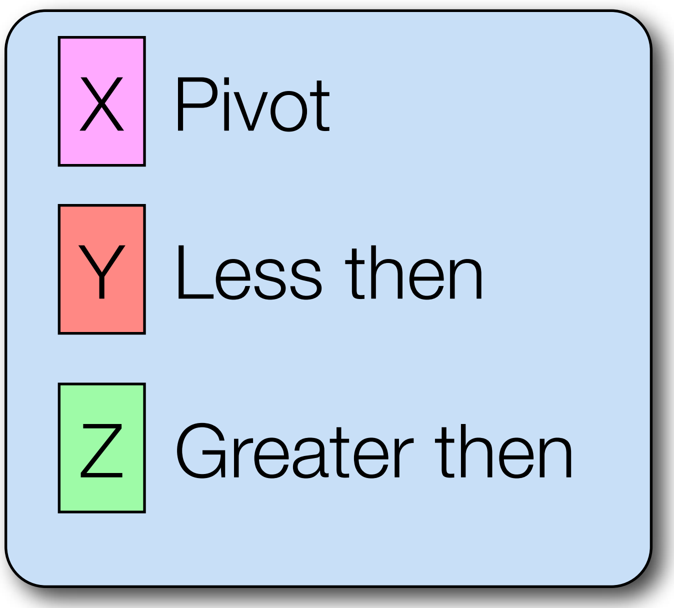
```
class Test {
   public static void main(String args[]) {
      int A, B, C;
      A=5;
      B=6;
      C=A+B;
      System.out.print(C);
   }
}
```

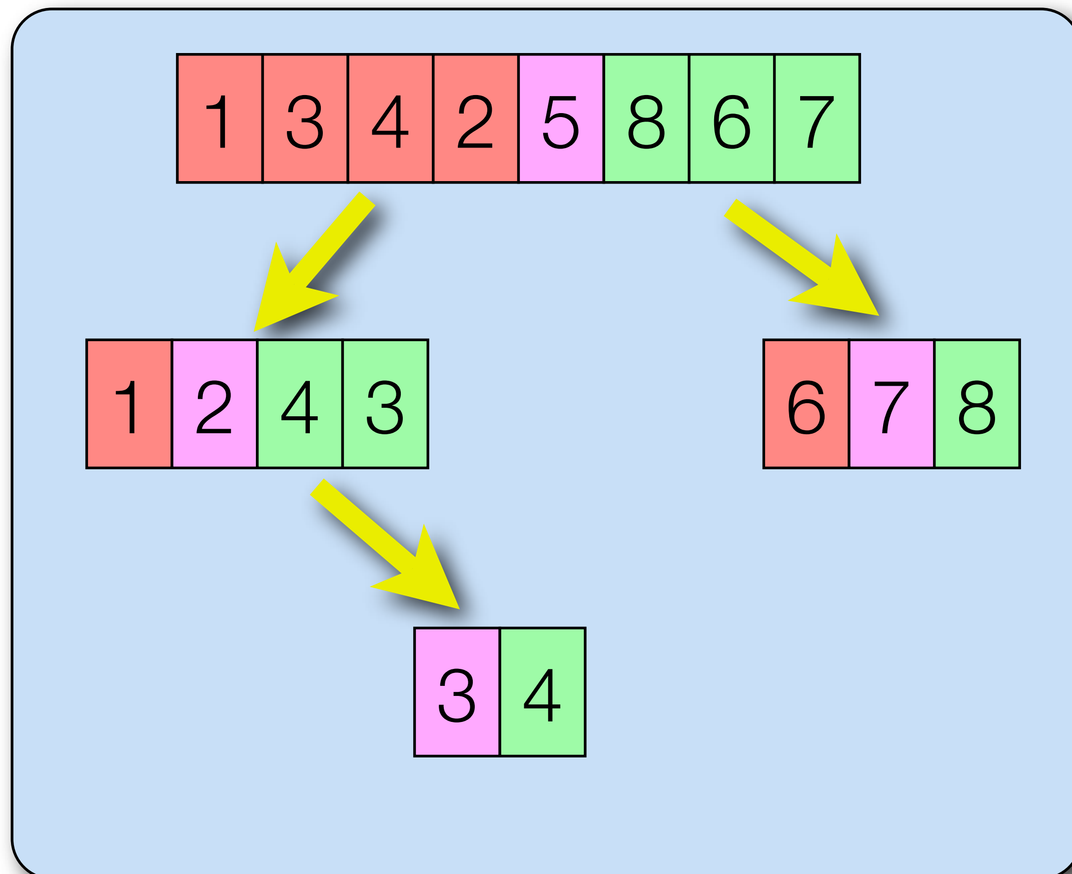
Declarative and Imperative programming

- There are two types of programming languages: **declarative** and **imperative**.
  - Declarative languages focus on **what** the computer should do.
  - Imperative languages focus on **how** the computer should do something.

Quicksort

- Quicksort sorts an array by **recursively** sorting "sub-arrays" as less than or greater than **pivot values**.





Quicksort in Haskell

```
qsort []       = []
qsort (x:xs) = qsort lt_x ++ [x] ++ qsort ge_x
     where
       lt_x = [y | y <- xs, y < x]
       ge_x = [y | y <- xs, y >= x]
```

Quicksort in Haskell

If input is **empty** return **empty**.

```
qsort []     = []
qsort (x:xs) = qsort lt_x ++ [x] ++ qsort ge_x
     where
        lt_x = [y | y <- xs, y < x]
        ge_x = [y | y <- xs, y >= x]
```

Otherwise, return a list with all the values **less than x** both **“qsort”ed** and **before x** and all values **greater than x** both **“qsort”ed** and **after x**.

```
qsort []     = []
qsort (x:xs) = qsort lt_x ++ [x] ++ qsort ge_x
    where
      lt_x = [y | y <- xs, y < x]
      ge_x = [y | y <- xs, y >= x]
```

This junk defines `lt_x` as all values **less than x**, and `ge_x` as all values **greater than or equal to x**.

```
qsort []     = []
qsort (x:xs) = qsort lt_x ++ [x] ++ qsort ge_x
    where
      lt_x = [y | y <- xs, y < x]
      ge_x = [y | y <- xs, y >= x]
```

Quicksort in C

```
qsort( a, lo, hi ) int a[], hi, lo;{
  int h, w, p, t;
  if (lo < hi) {
    w = lo;
    h = hi;
    p = a[hi];
    do {
      while ((w < h) && (a[w] <= p))
          w = w+1;
      while ((h > w) && (a[h] >= p))
          h = h-1;
```

```
if (w < h) {
            t = a[w];
           a[w] = a[h];
           a[h] = t;
       }
     } while (w < h);

     t = a[w];
     a[w] = a[hi];
     a[hi] = t;

     qsort( a, lo, w-1 );
     qsort( a, w+1, hi );
   }
}
```

Q

Find the **first element larger than the pivot** value and the **last element smaller than the pivot value**.

```
qsort( a, lo, hi ) int a[], hi, lo;{
  int h, w, p, t;
  if (lo < hi) {
    w = lo;
    h = hi;
    p = a[hi];
    do {
      while ((w < h) && (a[w] <= p))
          w = w+1;
      while ((h > w) && (a[h] >= p))
          h = h-1;
```

```
                t = a[w];
                a[w] = a[h];
                a[h] = t;
            }
        } while (w < h);

        t = a[w];
        a[w] = a[hi];
        a[hi] = t;

        qsort( a, lo, w-1 );
        qsort( a, w+1, hi );
    }
}
```

If these values are on the **"wrong side"** of the pivot, **swap them**.

```
qsort( a, lo, hi ) int a[], hi, lo;{
  int h, w, p, t;
  if (lo < hi) {
    w = lo;
    h = hi;
    p = a[hi];
    do {
      while ((w < h) && (a[w] <= p))
          w = w+1;
      while ((h > w) && (a[h] >= p))
          h = h-1;
      if (w < h) {
          t = a[w];
          a[w] = a[h];
          a[h] = t;
      }
    } while (w < h);

    t = a[w];
    a[w] = a[hi];
    a[hi] = t;

    qsort( a, lo, w-1 );
    qsort( a, w+1, hi );
  }
}
```

Repeat until no values are on the “**wrong side**.”

```
qsort( a, lo, hi ) int a[], hi, lo; {
  int h, w, p, t;
  if (lo < hi) {
    w = lo;
    h = hi;
    p = a[hi];
    do {
      while ((w < h) && (a[w] <= p))
          w = w+1;
      while ((h > w) && (a[h] >= p))
          h = h-1;
```

```
if (w < h) {
          t = a[w];
         a[w] = a[h];
         a[h] = t;
      }
    } while (w < h);

    t = a[w];
    a[w] = a[hi];
    a[hi] = t;

    qsort( a, lo, w-1 );
    qsort( a, w+1, hi );
  }
}
```

Swap the **smallest value greater than or equal to the pivot** with the **pivot**, which is at the end of the list

```
qsort( a, lo, hi ) int a[], hi, lo {
  int h, w, p, t;
  if (lo < hi) {
    w = lo;
    h = hi;
    p = a[hi];
    do {
      while ((w < h) && (a[w] <= p))
          w = w+1;
      while ((h > w) && (a[h] >= p))
          h = h-1;
```

```
      if (w < h) {
               t = a[w];
             a[w] = a[h];
             a[h] = t;
        }
    } while (w < h);

    t = a[w];
    a[w] = a[hi];
    a[hi] = t;

    qsort( a, lo, w-1 );
    qsort( a, w+1, hi );
  }
}
```

Quicksort in C

```
qsort( a, lo, hi
  int h, w, p, t;
  if (lo < hi) {
    w = lo;
    h = hi;
    p = a[hi];
    do {
      while ((w < h) && (a[w] <= p))
          w = w+1;
      while ((h > w) && (a[h] >= p))
          h = h-1;
```

Finally, recurse on the two sides.

```
if (w < h) {
            ;
            h];
            ;
      }
    } while (w < h);

    t = a[w];
    a[w] = a[hi];
    a[hi] = t;

    qsort( a, lo, w-1 );
    qsort( a, w+1, hi );
  }
}
```

Quicksort in C

```
qsort( a, lo, hi ) int a[], hi, lo;{
  int h, w, p, t;
  if (lo < hi) {
    w = lo;
    h = hi;
    p = a[hi
    do {
      while
          w
      while
          h
```

```
  if (w < h) {
             t = a[w];
            a[w] = a[h];
            a[h] = t;
        }
                              );
      qsort( a, w+1, hi );
    }
  }
```

Notice how much more **complex** this program is in C (an imperative language) than Haskell (a declarative language).

Quicksort in C

```
qsort( a, lo, hi ) int a[], hi, lo;{
  int h, w, p, t;
  if (lo < hi) {
    w = lo;
    h = hi;
    p = a[hi
    do {
      while
         w
      while
         h
```

```
if (w < h) {
            t = a[w];
           a[w] = a[h];
           a[h] = t;
        }
                          );
      qsort( a, w+1, hi );
   }
}
```

However, without a very good compiler, the quicksort in C **will likely run faster** than in Haskell!

Types of Languages

Declarative

Functional
e.g, Haskell & Lisp

Dataflow
e.g, Id & Val

Logic
e.g, Prolog

Imperative

Von Neumann
e.g, Fortran, Basic, & C

Object-Oriented
e.g, C++ & Java

Scripting
e.g, Perl

Types o

Functional languages are based on **functions** and **recursion**.

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Types

Dataflow languages focus on the flow of information between **nodes**.

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Logic languages model programs as a series of **logical statements**.

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Von Neumann languages allow for computation by focusing on **manipulating data elements**.

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Dataflow
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e.g, Prolog

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Von Neumann
e.g, Fortran, Basic, & C

Object-Oriented
e.g, C++ & Java

Scripting
e.g, Perl

Object-oriented languages allow for computation by modeling principles as a series of **semi-independent "objects"** .

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Scripting
e.g, Perl

Scripting languages are a subset of von Neumann languages and are serve as "**glue**" between more robust languages in order to **facilitate rapid development**.

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e.g, Perl

Course Topics

- Tentative List:
  - Compilation & Interpretation
  - Syntax Specification & Analysis
  - Names, Binding, & Scope
  - Control Flow
  - Data Types
  - Subroutines & Control Abstraction
  - Concurrency
  - Code Improvement
  - Data Abstraction & Object Orientation
  - Scripting Languages: Perl, Python, Ruby, etc..
  - Functional Languages: ML, Lisp/Scheme, Haskell, etc…
  - Logic Languages: Prolog
  - and more…