University of British Columbia CPSC 111, Intro to Computation 2009W2: Jan-Apr 2010

Tamara Munzner

Languages, Whitespace, Identifiers

Lecture 3, Mon Jan 11 2010

borrowing from slides by Kurt Eiselt, Wolfgang Heidrich, Alan Hu

http://www.cs.ubc.ca/~tmm/courses/111-10

News

- labs and tutorials start this week

- my office hours: Mon 4-5, or by appointment
    - in X661

- UBC CS news

Department of Computer Science
Undergraduate Events

Events this week

Drop-In Resume Edition

Date: Mon. Jan 11
Time: 11 am – 2 pm
Location: Rm 255, ICICS/CS

Industry Panel

Speakers: Managers from IBM, Microsoft, SAP, TELUS, Radical …
Date: Tues. Jan 12
Time: Panel: 5:15 – 6:15 pm
Networking: 6:15 – 7:15 pm
Location: DMP 110 for panel,
X-wing ugrad lounge for networking

Tech Career Fair

Date: Wed. Jan 13
Time: 10 am – 4 pm
Location: SUB Ballroom

Google Tech Talk

Date: Wed, Jan 13
Time: 4 – 5 pm
Location: DMP 110

IBM Info Session

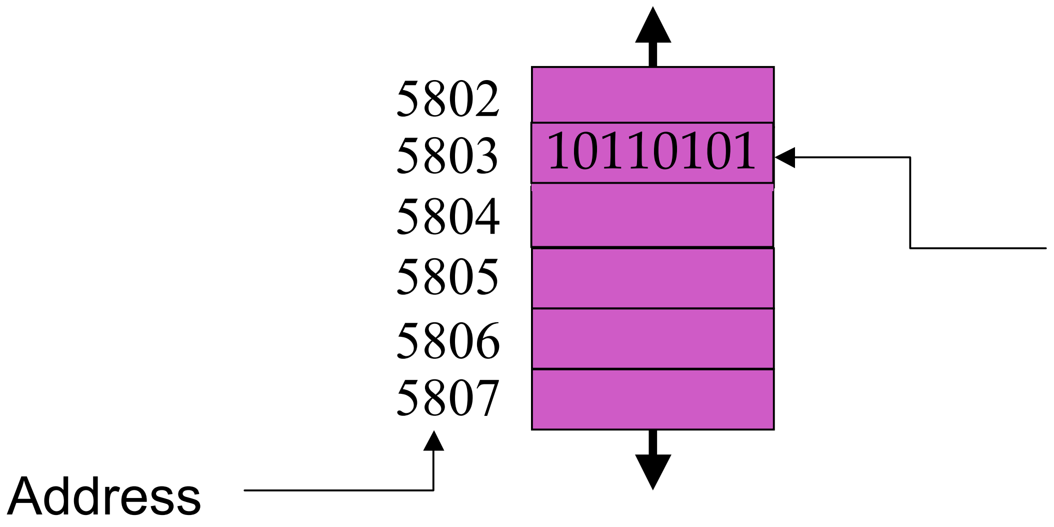
Date: Wed, Jan 13
Time: 5:30 – 7 pm
Location: Wesbrook 100

Reading This Week

- Chap 1: 1.3-1.8
- Chap 2: 2.1-2.2, 2.5
- Chap 4: 4.1-4.2

Review: Memory

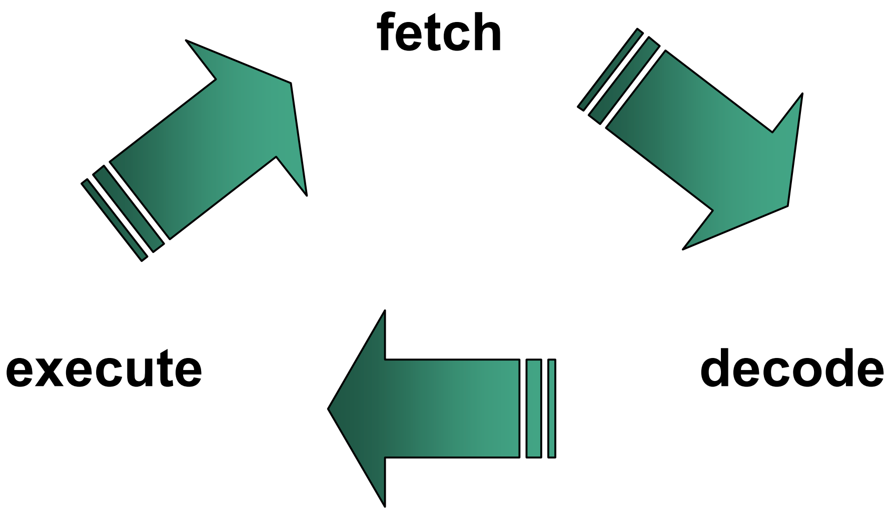
- Memory consists of a series of locations, each having a unique address, that are used to store programs and data.
- When data is stored in a memory location, the data that was previously stored there is overwritten and destroyed.
- Each memory location stores one byte (or 8 bits) of data.
  - Each bit is a 0 or a 1
    - More on this soon



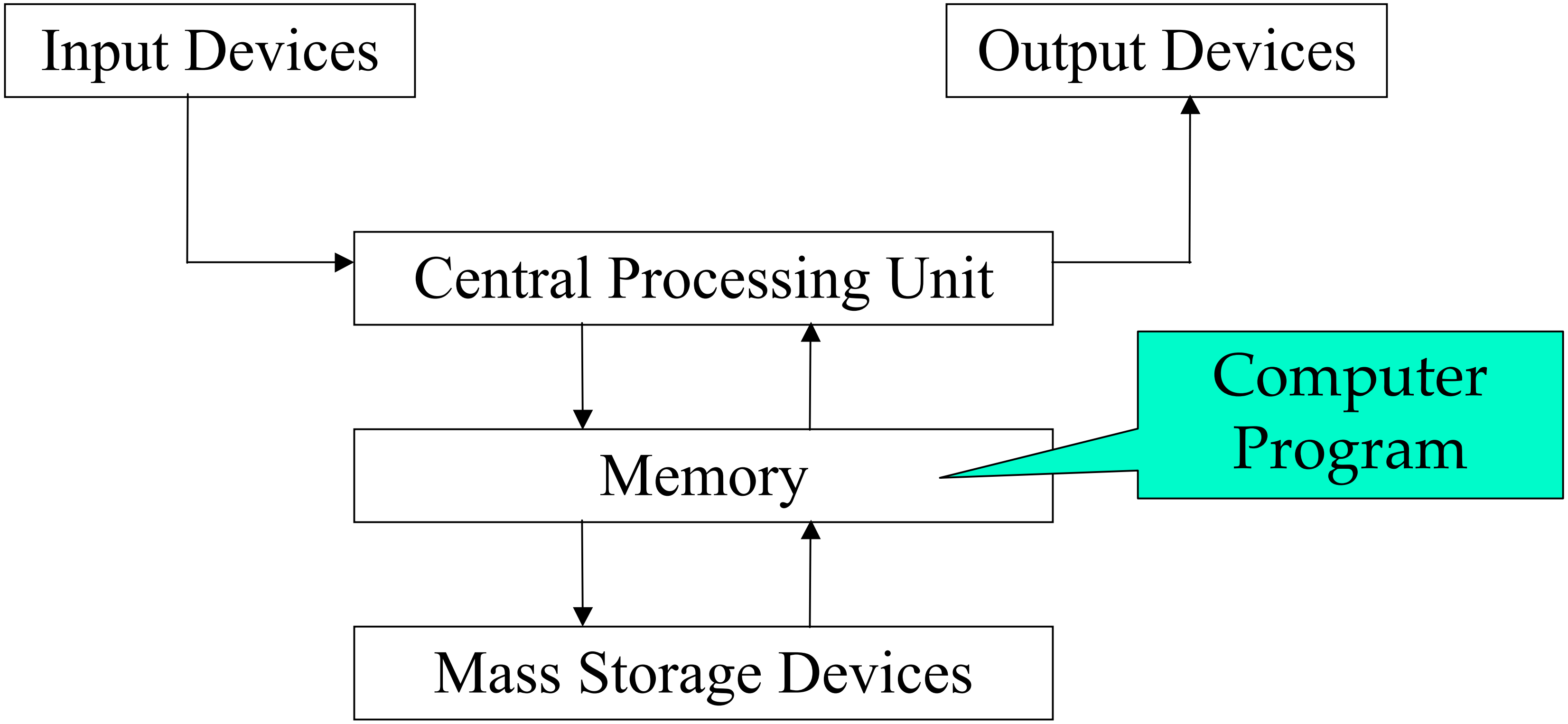
Data values are stored in memory locations – more than one location may be used if the data is large.

Review: Central Processing Unit

- CPU executes instructions in a continuous cycle
  - known as the "fetch-decode-execute" cycle
- CPU has dedicated memory locations known as **registers**
  - One register, the **program counter**, stores the address in memory of the next instruction to be executed



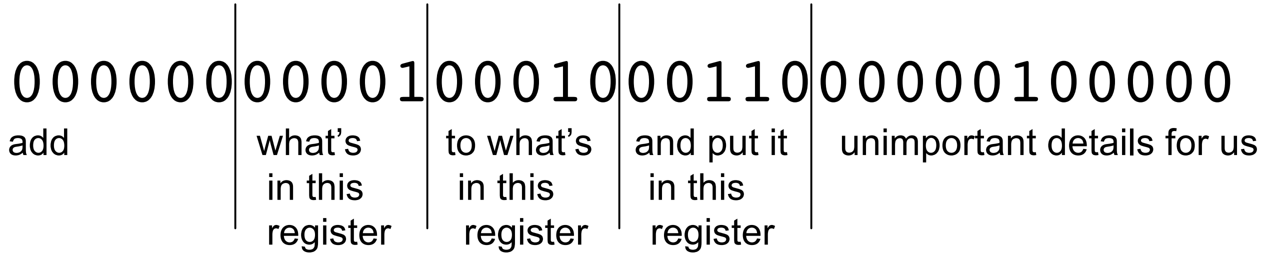
Review: Computer Programming



Review: Machine Language

- First programming languages: machine languages
  - Most primitive kind

- Sample machine language instruction
  - Register: special purpose memory location inside CPU where real computation occurs



000000 | 00001 | 00010 | 00110 | 00000100000

add | what's in this register | to what's in this register | and put it in this register | unimportant details for us

- Difficult to write programs this way
  - People created languages that were more readable

Review: Assembly Language

- Next: assembly languages
    - Direct mappings of machine language instructions into helpful mnemonics, abbreviations
- Sample assembly language instruction
    - Corresponds to machine language instructions

```
add r1,r2,r6
```

000000	00001	00010	00110	00000100000
add	what's in this register	to what's in this register	and put it in this register	unimportant details for us

Review: Binary vs. Decimal Numbers

- decimal system numbers
  - have digits 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
- read from right to left:
  - ones (10^0), tens (10^1), hundreds (10^2), thousands (10^3), ...
  - ex: 4763 means $3*10^0+6*10^1+7*10^2+4*10^3$
  - the exponents count up from 0
- binary system numbers
  - have digits 0, 1
- still read from right to left:
  - ones (2^0), twos (2^1), fours (2^2), eights (2^3), sixteens (2^4), ...
  - ex: 10010111 means: $1*2^0+1*2^1+1*2^2+0*2^3+1*2^4+0*2^5+0*2^6+1*2^7$

    $= 1+2+4+16+128 = 151$

Aside – Other Bases

- The same principle works for other bases
- For example, *hexadecimal* (base 16)
  - uses digits 0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F
  - A-F correspond to values 10-15
- Example:

C350

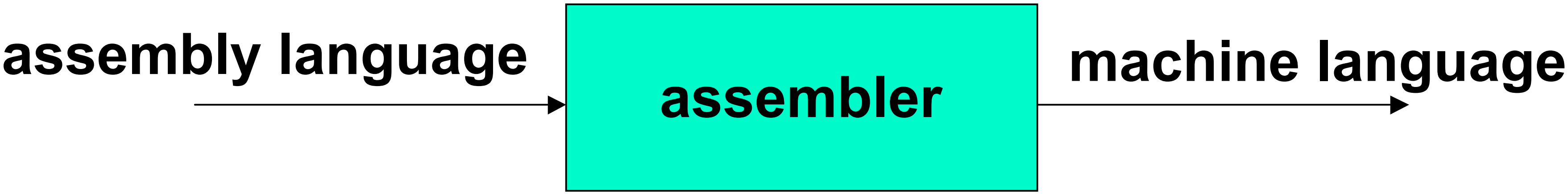
- Means:

$$0*16^0 + 5*16^1 + 3*16^2 + 12*16^3$$

$$= 5*16 + 3*256 + 12*4096 = 50{,}000$$

Assembly Language

- Assembly language program converted into corresponding machine language instructions by another program called an assembler



```
add r1,r2,r6
```

000000	00001	00010	00110	00000100000
add	what's in this register	to what's in this register	and put it in this register	unimportant details for us

Assembly Language

- Both machine and assembly languages pose big challenges for programmers
  - Difficult to read and write
  - Difficult to remember
- Each instruction does very little
  - Takes lots of instructions just to get something simple done
- Every machine or assembly language good for only one type of computer
  - Different to program IBM than Honeywell than Burroughs...

High-Level Language

- Next step: development of high-level languages

- You may have heard of some
  - Fortran, COBOL, Lisp, BASIC, C, C++, C#, Ada, Perl, Java, Python, Ruby, Javascript

- High-level languages intended to be easier to use
  - still a long way from English.

- A single high-level instruction gets more work done than a machine or assembly language instruction.

- Most high-level languages can be used on different computers

Java

- Java is the high-level language we’ll use.
  - Modern, widely used, portable, safe.

- Developed by Sun in early 1990s
  - Originally intended for set-top boxes
  - Retargeted for the Web

High-Level Language

- Example of a high-level instruction
  - A = B + C

- Tells computer to
  - go to main memory and find value stored in location called B
  - go to main memory and find value stored in location called C
  - add those two values together
  - store result in memory in location called A

High-Level Language

- Must be translated into machine language so the computer can understand it.

- High-level instruction: A = B + C

becomes at least four machine language instructions!

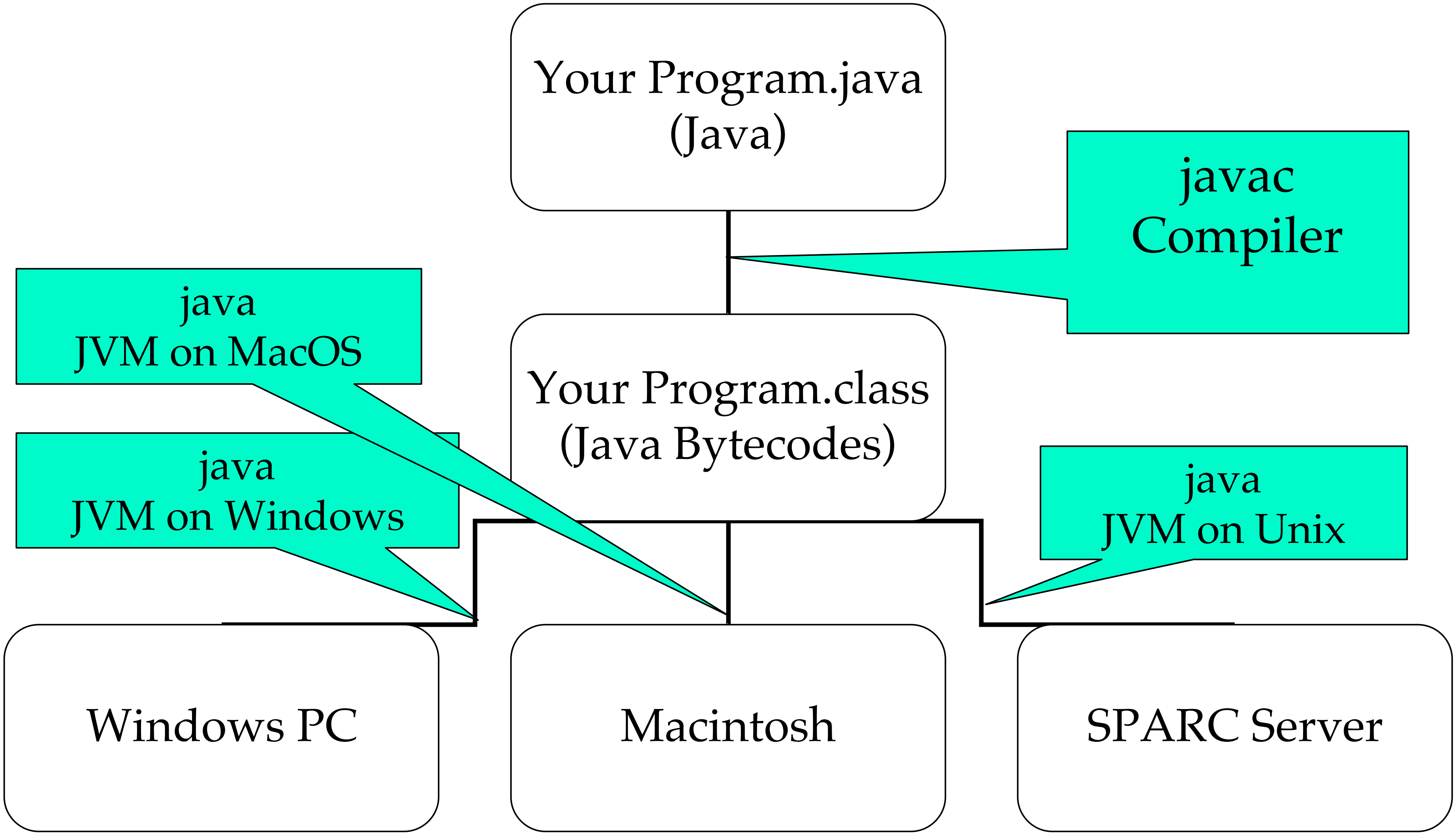
```
00010000001000000000000000000010   load B
00010000010000000000000000000011   load C
00000000001000100011000000100000   add them
00010100110000000000000000000001   store in A
```

- How?
  - You could translate it as you go (**interpreter**).
  - You could translate it in advance (**compiler**).

Interpreters and Compilers

- An interpreter translates the high-level language into machine language on-the-fly, executing the instructions as it goes.
- A compiler translates the high-level language program all at once in advance.
- Both compilers and interpreters are themselves computer programs.
- Which is better?
  - Remember George and Stephen in France?

Java Does Both!



A Simple Java Program

```
// Our first Java program.
/* Traditionally, one’s first program in a new
  language prints out “Hello, World!”
*/
class HelloTester {
  public static void main(String[] args) {
   System.out.println("Hello, World!");
  }
}
```

Sample Java Application Program

```
//*******************************************************
// Oreo.java        Author:  Kurt Eiselt
//
// Demonstrating simple Java programming concepts while
// revealing one of Kurt's many weaknesses
//*******************************************************

public class Oreo
{
  //*****************************************************
  // demand Oreos
  //*****************************************************
  public static void main (String[] args)
  {
    System.out.println ("Feed me more Oreos!");
  }
}
```

Sample Java Application Program

- Comments ignored by Java compiler

```
//*******************************************************
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//*******************************************************

public class Oreo
{
  //*****************************************************
  // demand Oreos
  //*****************************************************
  public static void main (String[] args)
  {
    System.out.println ("Feed me more Oreos!");
  }
}
```

Sample Java Application Program

- Comments could also look like this

```
/*
   Oreo.java        Author:  Kurt Eiselt

   Demonstrating simple Java programming concepts while
   revealing one of Kurt's many weaknesses
*/

public class Oreo
{
  /* demand Oreos */
  public static void main (String[] args)
  {
    System.out.println ("Feed me more Oreos!");
  }
}
```

Sample Java Application Program

```
public class Oreo
{
  public static void main (String[] args)
  {
    System.out.println ("Feed me more Oreos!");
  }
}
```

- Comments are important to people
  - But not to the compiler
- Compiler only cares about

Sample Java Application Program

```java
public class Oreo
{
  public static void main (String[] args)
  {
    System.out.println ("Feed me more Oreos!");
  }
}
```

- Whole thing is the definition of a class
  - Package of instructions that specify
    - what kinds of data will be operated on
    - what kinds of operations there will be
  - Java programs will have one or more classes
    - For now, just worry about one class at a time

Sample Java Application Program

```
public class Oreo
{
  public static void main (String[] args)
  {
    System.out.println ("Feed me more Oreos!");
  }
}
```

- Instructions inside class definition grouped into one or more procedures called methods
  - group of Java statements (instructions) that has name, performs some task
- All Java programs you create will have main method where program execution begins

Sample Java Application Program

```
public class Oreo
{
  public static void main (String[] args)
  {
    System.out.println ("Feed me more Oreos!");
  }
}
```

- These class and method definitions are incomplete at best
  - good enough for now
  - expand on these definitions as class continues

Sample Java Application Program

```
public class Oreo
{
  public static void main (String[] args)
  {
    System.out.println ("Feed me more Oreos!");
  }
}
```

- Words we use when writing programs are called identifiers
  - except those inside the quotes

Sample Java Application Program

```
public class Oreo
{
  public static void main (String[] args)
  {
    System.out.println ("Feed me more Oreos!");
  }
}
```

- Kurt made up identifier Oreo

Sample Java Application Program

```
public class Oreo
{
  public static void main (String[] args)
  {
    System.out.println ("Feed me more Oreos!");
  }
}
```

- Other programmers chose identifier System.out.println
  - they wrote printing program
  - part of huge library of useful programs that comes with Java

Sample Java Application Program

```java
public class Oreo
{
  public static void main (String[] args)
  {
    System.out.println ("Feed me more Oreos!");
  }
}
```

- Special identifiers in Java called reserved words
  - don’t use them in other ways

Reserved Words

- Get familiar with these
  - But you don’t need to memorize all 52 for exam

abstract
boolean
break
byte
case
catch
char
class
const
continue
default
do
double
else
enum
extends
false
final
finally
float
for
goto
if
implements
import
instanceof
int
interface
long
native
new
null
package
private
protected
public
return
short
static
strictfp
super
switch
synchronized
this
throw
throws
transient
true
try
void
volatile
while

Identifiers

- Identifier must
  - Start with a letter and be followed by
  - Zero or more letters and/or digits
    - Digits are 0 through 9.
    - Letters are the 26 characters in English alphabet
      - both uppercase and lowercase
      - plus the $ and _
      - also alphabetic characters from other languages

Identifiers

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      - both uppercase and lowercase
      - plus the $ and _
      - also alphabetic characters from other languages
  - Which of the following are not valid identifiers?

```
userName      user_name      $cash      2ndName

first name    user.age       _note_     note2
```

Identifiers

- Identifier must
  - Start with a letter and be followed by
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      - both uppercase and lowercase
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      - also alphabetic characters from other languages
  - Which of the following are not valid identifiers?

`userName`	`user_name`	`$cash`	`2ndName`
`first name`	`user.age`	`_note_`	`note2`

Identifiers

- Java is case sensitive
- Oreo oreo OREO 0reo
  - are all different identifiers, so be careful
  - common source of errors in programming

Identifiers

- Java is case sensitive
- Oreo   oreo   OREO   0reo
  - are all different identifiers, so be careful
  - common source of errors in programming

  - are these all valid identifiers?

Identifiers

- Creating identifiers in your Java programs
  - Remember other people read what you create
  - Make identifiers meaningful and descriptive for both you and them
- No limit to how many characters you can put in your identifiers
  - but don’t get carried away

```
public class ReallyLongNamesWillDriveYouCrazyIfYouGoOverboard
{
  public static void main (String[] args)
  {
    System.out.println ("Enough already!");
  }
}
```

White Space

```
//*******************************************************
// Oreo.java        Author:  Kurt Eiselt
//
// Demonstrating good use of white space
//*******************************************************

public class Oreo
{
  public static void main (String[] args)
  {
    System.out.println ("Feed me more Oreos!");
  }
}
```

White Space

```
//*******************************************************
// Oreo1.java       Author:  Kurt Eiselt
//
// Demonstrating mediocre use of white space
//*******************************************************

public class Oreo1
{
public static void main (String[] args)
{
System.out.println ("Feed me more Oreos!");
}
}
```

White Space

```
//*******************************************************
// Oreo2.java       Author:  Kurt Eiselt
//
// Demonstrating bad use of white space
//*******************************************************

public class Oreo2 { public static void main (String[]
args) { System.out.println ("Feed me more Oreos!"); } }
```

White Space

```
//*******************************************************
// Oreo3.java        Author:  Kurt Eiselt
//
// Demonstrating totally bizarre use of white space
//*******************************************************

    public
class     Oreo3
        {
  public  static
void main  (String[] args)
                              {
  System.out.println   ("Feed me more Oreos!")
;
        }
             }
```

White Space

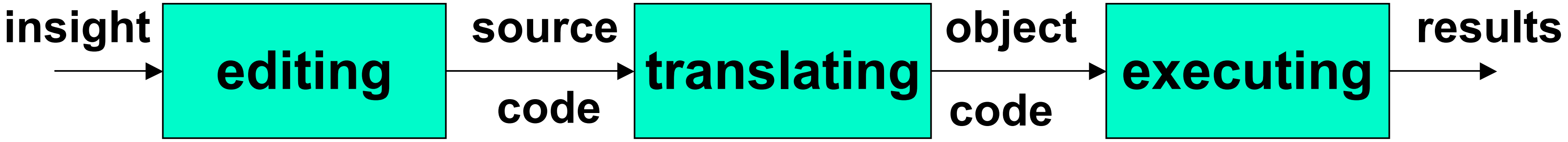
```
//*******************************************************
// Oreo4.java       Author:  Kurt Eiselt
//
// Demonstrating deep psychological issues with whitespace
//*******************************************************

public
class
Oreo4
{
public
static
void
main
(
String[]
args
)
{
System.out.println
("Feed me more Oreos!")
;
}
}
```

White Space

- White space
  - Blanks between identifiers and other symbols
  - Tabs and newline characters are included
- White space does not affect how program runs
- Use white space to format programs we create so they’re easier for people to understand

Program Development

- Use an editor to create your Java program
  - often called source code
  - code used interchangeably with program or instructions in the computer world
- Another program, a compiler or an interpreter, translates source code into target language or object code, which is often machine language
- Finally, your computer can execute object code



Compiling and Running

- Let’s try it!
  - command line for now
  - later we’ll use Eclipse
    - integrated development environment (IDE)

Syntax

- Rules to dictate how statements are constructed.
  - Example: open bracket needs matching close bracket
- If program is not syntactically correct, cannot be translated by compiler
- Different than humans dealing with natural languages like English. Consider statement with incorrect syntax (grammar)

  for weeks. rained in Vancouver it hasn’t

  - we still have pretty good shot at figuring out meaning

Semantics

- What will happen when statement is executed
- Programming languages have well-defined semantics, no ambiguity
- Different than natural languages like English. Consider statement:

  Mary counted on her computer.

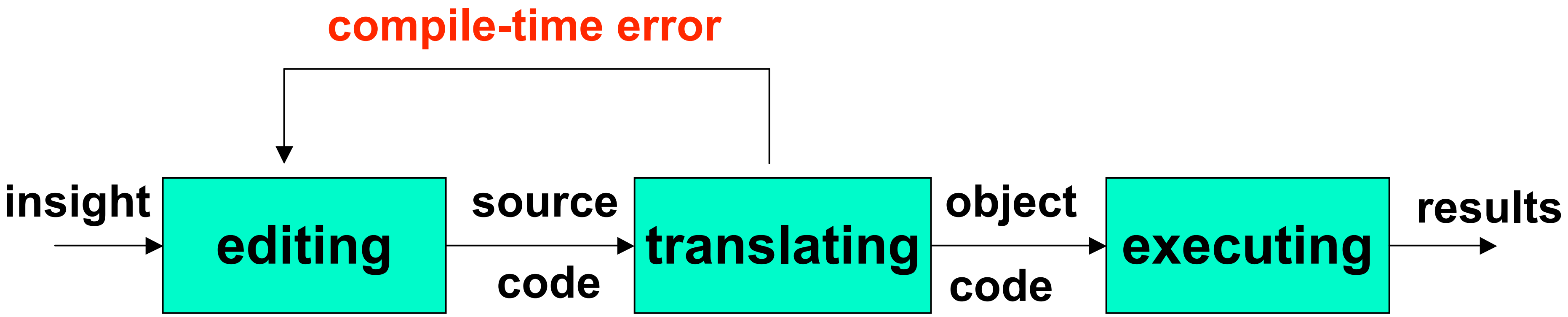
- How could we interpret this?

- Programming languages cannot allow for such ambiguities or computer would not know which interpretation to execute

Errors

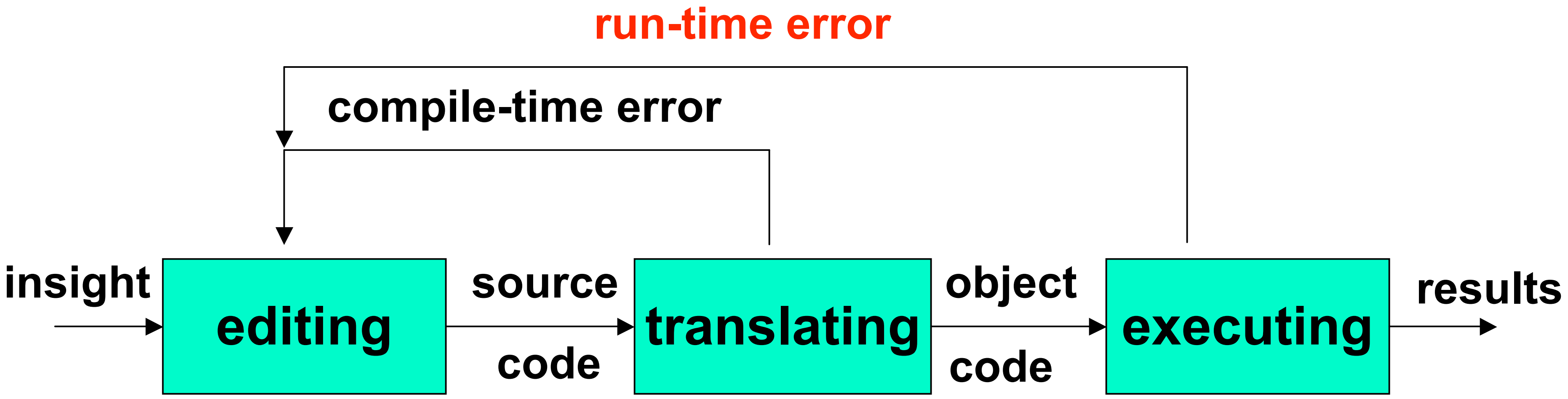
- Computers follows our instructions exactly
- If program produces the wrong result it's the programmer's fault
  - unless the user inputs incorrect data
  - then cannot expect program to output correct results: "Garbage in, garbage out" (GIGO)
- Debugging: process of finding and correcting errors
  - Unfortunately can be very time consuming!

Errors



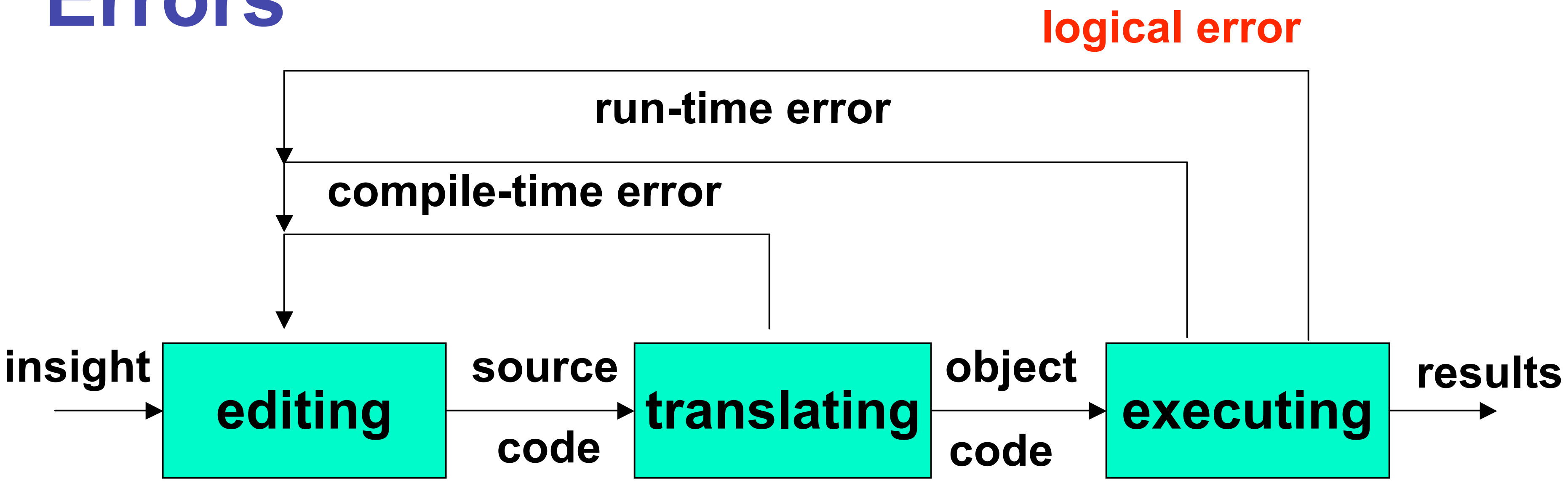
- Error at compile time (during translation)
  - you did not follow syntax rules that say how Java elements must be combined to form valid Java statements

Errors



- Error at run time (during execution)
  - Source code compiles
    - Syntactically (structurally) correct
  - But program tried something computers cannot do
    - like divide a number by zero.
  - Typically program will crash: halt prematurely

Errors



- Logical error
  - Source code compiles
  - Object code runs
  - But program may still produce incorrect results because logic of your program is incorrect
    - Typically hardest problems to find

Errors

- Let’s try it!
  - usually errors happen by mistake, not on purpose...

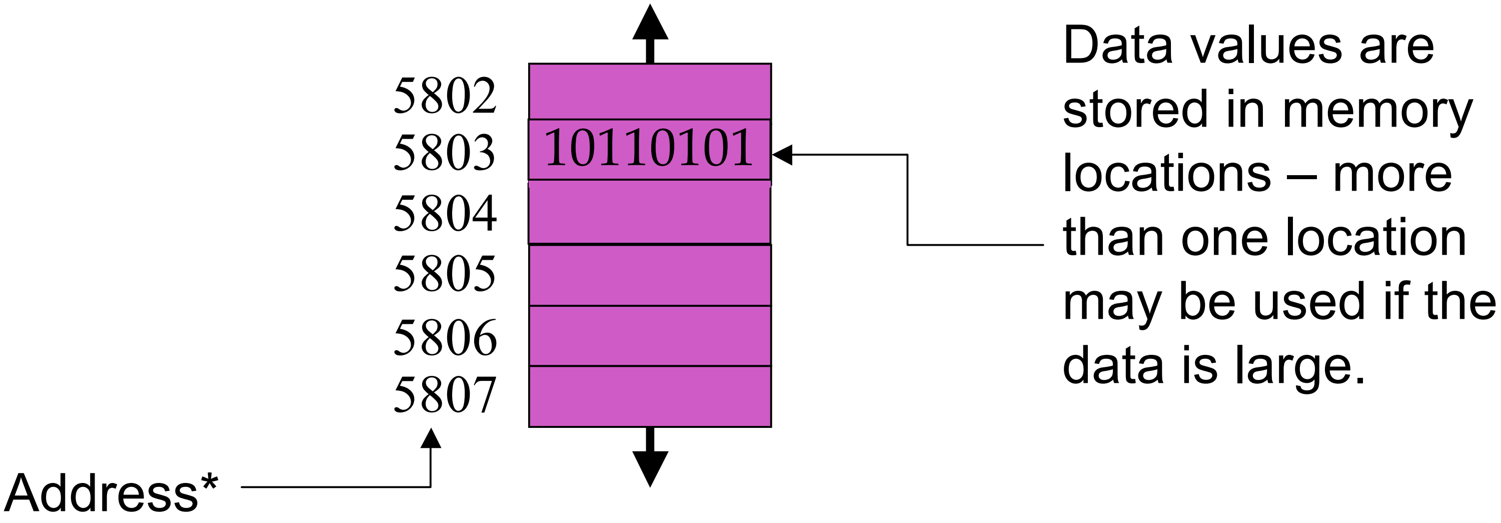
Memory and Identifiers

- Example of a high-level instruction
  - A = B + C
- Tells computer to
  - go to main memory and find value stored in location called B
  - go to main memory and find value stored in location called C
  - add those two values together
  - store result in memory in location called A

- Great! But... in reality, locations in memory are not actually called things like a, b, and c.

Memory Recap

- Memory: series of locations, each having a unique address, used to store programs and data
- When data is stored in a memory location, previously stored data is overwritten and destroyed
- Each memory location stores one byte (8 bits) of data



Data values are stored in memory locations – more than one location may be used if the data is large.

Address*

*For total accuracy, these addresses should be binary numbers, but you get the idea, no?

Memory and Identifiers

- So what's with the a, b, and c?
  - Machine language uses actual addresses for memory locations
  - High-level languages easier
    - Avoid having to remember actual addresses
    - Invent meaningful identifiers giving names to memory locations where important information is stored
- `pay_rate` and `hours_worked` vs. 5802 and 5806
  - Easier to remember and a whole lot less confusing!

Memory and Identifiers: Variables

- Variable: name for location in memory where data is stored
  - like variables in algebra class

- `pay_rate`, `hours_worked`, `a`, `b`, and `c` are all variables

- Variable names begin with lower case letters
  - Java convention, not compiler/syntax requirement

- Variable may be name of single byte in memory or may refer to a group of contiguous bytes
  - More about that next time

Programming With Variables

```
//*****************************************
// Test.java       Author: Kurt
//
// Our first use of variables!
//*****************************************

public class Test
{
    public static void main (String[] args)
    {
        a = b + c;
        System.out.println ("The answer is " + a);
    }
}
```

- Let’s give it a try...

Programming With Variables

```
//*****************************************
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public class Test
{
    public static void main (String[] args)
    {
        a = b + c;
        System.out.println ("The answer is " + a);
    }
}
```

- Let’s give it a try...
  - b and c cannot be found!
  - need to assign values

Programming With Variables: Take 2

```
//****************************************
// Test2.java      Author: Kurt
//
// Our second use of variables!
//****************************************

public class Test2
{
    public static void main (String[] args)
    {
        b = 3;
        c = 5;
        a = b + c;
        System.out.println ("The answer is " + a);
    }
}
```

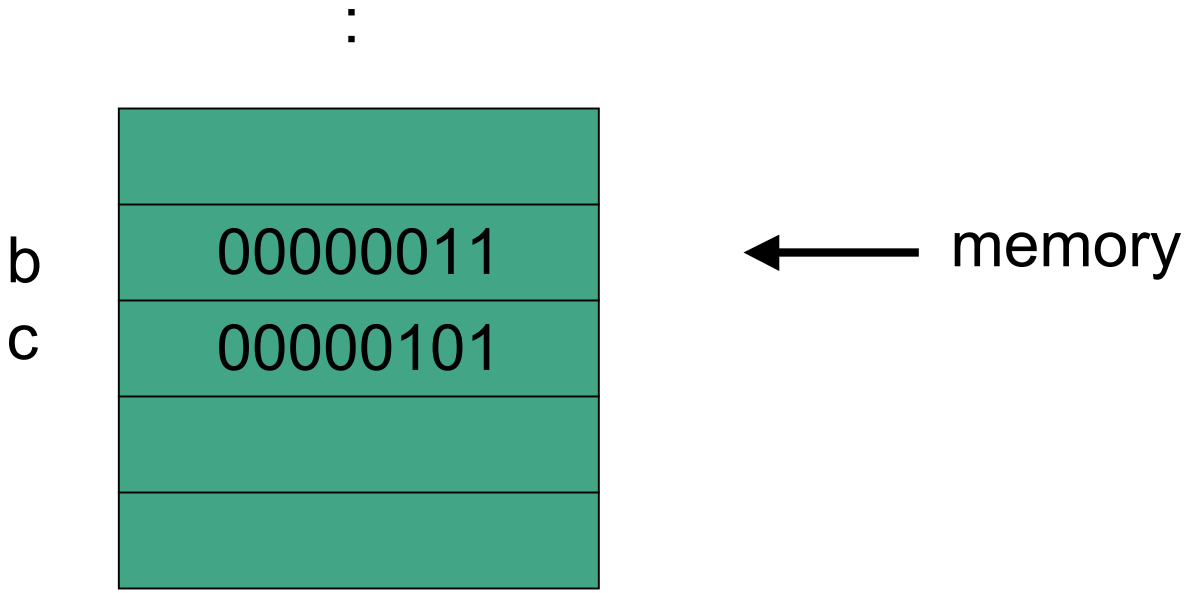
Programming With Variables: Take 2

```
//*****************************************
// Test2.java       Author: Kurt
//
// Our second use of variables!
//*****************************************

public class Test2
{
    public static void main (String[] args)
    {
        b = 3;
        c = 5;
        a = b + c;
        System.out.println ("The answer is " + a);
    }
}
```

- Now what?
  - such a lazy computer, still can’t find symbols...

Now What?



- Java doesn’t know how to interpret the contents of the memory location
  - are they integers? characters from the keyboard? shades of gray? or....

Data Types

- Java requires that we tell it what kind of data it is working with
- For every variable, we have to declare a data type
- Java language provides eight primitive data types
  - i.e. simple, fundamental
- For more complicated things, can use data types
  - created by others provided to us through the Java libraries
  - that we invent
    - More soon - for now, let's stay with the primitives
- We want `a`, `b`, and `c` to be integers. Here's how we do it...

Programming With Variables: Take 3

```
//*****************************************
// Test3.java       Author: Kurt
//
// Our third use of variables!
//*****************************************

public class Test3
{
    public static void main (String[] args)
    {
        int a;  //these
        int b;  //are
        int c;  //variable declarations
        b = 3;
        c = 5;
        a = b + c;
        System.out.println ("The answer is " + a);
    }
}
```

Primitive Data Types: Numbers

Type	Size	Min	Max
`byte`	1 byte	-128	127
`short`	2 bytes	-32,768	32,767
`int`	4 bytes	-2,147,483,648	2,147,483,647
`long`	8 bytes	-9,223,372,036,854,775,808	9,223,372,036,854,775,807
`float`	4 bytes	approx -3.4E38 (7 sig.digits)	approx 3.4E38 (7 sig.digits)
`double`	8 bytes	approx -1.7E308 (15 sig. digits)	approx 1.7E308 (15 sig. digits)

- Six primitives for numbers
  - integer vs. floating point
  - fixed size, so finite capacity

Primitive Data Types: Non-numeric

- Character Type
  - named char
  - Java uses the Unicode character set so each char occupies 2 bytes of memory.
- Boolean Type
  - named boolean
  - Variables of type boolean have only two valid values
    - true and false
  - Often represents whether particular condition is true
  - More generally represents any data that has two states
    - yes/no, on/off

Primitive Data Types: Numbers

Type	Size	Min	Max
`byte`	1 byte	-128	127
`short`	2 bytes	-32,768	32,767
`int`	4 bytes	-2,147,483,648	2,147,483,647
`long`	8 bytes	-9,223,372,036,854,775,808	9,223,372,036,854,775,807
`float`	4 bytes	approx -3.4E38 (7 sig.digits)	approx 3.4E38 (7 sig.digits)
`double`	8 bytes	approx -1.7E308 (15 sig. digits)	approx 1.7E308 (15 sig. digits)

- Primary primitives are **`int`** and **`double`**
  - Just worry about those for now

Questions?