Still in the early research stage, but engineers at sister campus UCLA have developed an organic light-emitting diode that stretches, which could lead to electronics that can be rolled up like cloth.

www.technologyreview.com/computing/38439/
And in review...

- We represent “things” in computers as particular bit patterns: \( N \) bits \( \Rightarrow 2^N \) things
- These 5 integer encodings have different benefits; 1s complement and sign/mag have most problems.
- **unsigned** (C99’s `uintN_t`):
  - \( 00000 \ 00001 \ldots 01111 \ 10000 \ldots 11111 \)
  - 2’s complement (C99’s `intN_t`) universal, learn!
  - \( 00000 \ 00001 \ldots 01111 \)
  - \( 10000 \ldots 11110 \ 11111 \)
- Overflow: numbers \( \infty \); computers finite, errors!

META: We often make design decisions to make HW simple

META: Ain’t no free lunch
“Before this class, I (student) would say I am a solid C programmer”

a) Strongly disagree (never coded, and I don’t know Java or C++)

b) Mildly disagree (never coded, but I do know Java and/or C++)

c) Neutral (I’ve coded a little in C)

d) Mildly agree (I’ve coded a fair bit in C)

e) Strongly agree (I’ve coded a lot in C)
“Before this class, I (student) would say I am a solid Java programmer”

a) Strongly disagree (never coded, and I don’t know C or C++)

b) Mildly disagree (never coded, but I do know C and/or C++)

c) Neutral (I’ve coded a little in Java)

d) Mildly agree (I’ve coded a fair bit in Java)

e) Strongly agree (I’ve coded a lot in Java)
Has there been an update to ANSI C?

• Yes! It’s called the “C99” or “C9x” std
  • You need “gcc -std=c99” to compile

• References
  http://home.tiscalinet.ch/t_wolf/tw/c/c9x_changes.html

• Highlights
  • Declarations in for loops, like Java (#15)
  • Java-like // comments (to end of line) (#10)
  • Variable-length non-global arrays (#33)
  • <inttypes.h>: explicit integer types (#38)
  • <stdbool.h> for boolean logic def’s (#35)
Disclaimer

• **Important**: You will not learn how to fully code in C in these lectures! You’ll still need your C reference for this course.
  
  • K&R is a must-have reference
    ▪ Check online for more sources
  
  • “JAVA in a Nutshell,” O’Reilly.
    ▪ Chapter 2, “How Java Differs from C”
    ▪ http://oreilly.com/catalog/javanut/excerpt/
  
  • Brian Harvey’s course notes
    ▪ On CS61C class website
Compilation : Overview

C *compilers* take C and convert it into an *architecture specific* machine code (string of 1s and 0s).

- Unlike Java which converts to *architecture independent* bytecode.
- Unlike most Scheme environments which interpret the code.
- These differ mainly in *when* your program is converted to machine instructions.
- For C, generally a 2 part process of compiling .c files to .o files, then linking the .o files into executables. *Assembling* is also done (but is hidden, i.e., done automatically, by default)
Compilation : Advantages

• **Great run-time performance**: generally much faster than Scheme or Java for comparable code (because it optimizes for a given architecture)

• **OK compilation time**: enhancements in compilation procedure (Makefiles) allow only modified files to be recompiled
Compilation: Disadvantages

• All compiled files (including the executable) are **architecture specific**, depending on both the CPU type and the operating system.

• Executable must be **rebuilt** on each new system.
  
  • Called “**porting your code**” to a new architecture.

• The “change→compile→run [repeat]” iteration cycle is slow
C Syntax: `main`

• To get the main function to accept arguments, use this:

```c
int main (int argc, char *argv[])
```

• What does this mean?

  • `argc` will contain the number of strings on the command line (the executable counts as one, plus one for each argument). Here `argc` is 2:

    ```bash
    unix% sort myFile
    ```

  • `argv` is a pointer to an array containing the arguments as strings (more on pointers later).
C Syntax: Variable Declarations

• Very similar to Java, but with a few minor but important differences

• All variable declarations must go before they are used (at the beginning of the block)*

• A variable may be initialized in its declaration; if not, it holds garbage!

• Examples of declarations:
  • correct:  
    ```
    int a = 0, b = 10;
    ...
    ```
  • Incorrect:* for (int i = 0; i < 10; i++)

*C99 overcomes these limitations
Address vs. Value

• Consider memory to be a single huge array:
  • Each cell of the array has an address associated with it.
  • Each cell also stores some value.
  • Do you think they use signed or unsigned numbers? Negative address?!

• Don’t confuse the address referring to a memory location with the value stored in that location.

```
101 102 103 104 105 ...
...
23
...
```

42
Pointers

• An address refers to a particular memory location. In other words, it points to a memory location.

• **Pointer**: A variable that contains the address of a variable.
Pointers

• How to create a pointer:
  
  & operator: get address of a variable

  ```c
  int *p, x;
  p = &x;
  x = 3;
  ```

  Note the "*" gets used 2 different ways in this example. In the declaration to indicate that p is going to be a pointer, and in the `printf` to get the value pointed to by p.

• How get a value pointed to?
  
  * “dereference operator”: get value pointed to

  ```c
  printf("p points to %d\n", *p);
  ```
Pointers

• How to change a variable pointed to?
  • Use dereference * operator on left of =

\[
\begin{array}{c}
\text{p} & \text{x} & 3 \\
\end{array}
\]

\[
\begin{array}{c}
\text{p} & \text{x} & 5 \\
\end{array}
\]

\[\star{\text{p}} = 5;\]

\[\text{p} \quad \text{x} \quad 5\]
Pointers and Parameter Passing

• Java and C pass parameters “by value”
  • procedure/function/method gets a copy of the parameter, so changing the copy cannot change the original

void addOne (int x) {
    x = x + 1;
}

int y = 3;
addOne(y);

y is still = 3
Pointers and Parameter Passing

• How to get a function to change a value?

```c
void addOne (int *p) {
    *p = *p + 1;
}

int y = 3;

addOne (&y);

y is now = 4
```
Pointers

- Pointers are used to point to any data type (int, char, a struct, etc.).

- Normally a pointer can only point to one type (int, char, a struct, etc.).
  - `void *` is a type that can point to anything (generic pointer)
  - Use sparingly to help avoid program bugs... and security issues... and a lot of other bad things!
void main() { 
    int *p, x=5, y; // init 
    y = *(p = &x) + 1; 
    int z; 
    flip-sign(p); 
    printf("x=%d,y=%d,p=%d\n",x,y,p); 
}

flip-sign(int *n){*n = -(*n)}

How many syntax+logic errors in this C99 code?

<table>
<thead>
<tr>
<th>#Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) 1</td>
</tr>
<tr>
<td>b) 2</td>
</tr>
<tr>
<td>c) 3</td>
</tr>
<tr>
<td>d) 4</td>
</tr>
<tr>
<td>e) 5</td>
</tr>
</tbody>
</table>
Peer Instruction Answer

```c
void main() { 
  int *p, x=5, y; // init
  y = *(p = &x) + 1;
  int z;
  flip-sign(p);
  printf("x=%d,y=%d,p=%d\n",x,y,*p);
}
flip-sign(int *n){*n = -(*n);}
```

How many syntax+logic errors in this C99 code?

I get 5…

(signed ptr print is logical err)
And in conclusion…

• All declarations go at the beginning of each function except if you use C99.

• All data is in memory. Each memory location has an address to use to refer to it and a value stored in it.

• A **pointer** is a C version of the address.
  * “follows” a pointer to its value
  & gets the address of a value
## C vs. Java™ Overview (1/2)

<table>
<thead>
<tr>
<th>Java</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Object-oriented (OOP)</td>
<td>• No built-in object abstraction. Data separate from methods.</td>
</tr>
<tr>
<td>• “Methods”</td>
<td>• “Functions”</td>
</tr>
<tr>
<td>• Class libraries of data structures</td>
<td>• C libraries are lower-level</td>
</tr>
<tr>
<td>• <strong>Automatic memory management</strong></td>
<td>• <strong>Manual memory management</strong></td>
</tr>
<tr>
<td></td>
<td>• <strong>Pointers</strong></td>
</tr>
</tbody>
</table>
## C vs. Java™ Overview (2/2)

<table>
<thead>
<tr>
<th>Java</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>• High memory overhead from class libraries</td>
<td>• Low memory overhead</td>
</tr>
<tr>
<td>• Relatively Slow</td>
<td>• Relatively Fast</td>
</tr>
<tr>
<td>• Arrays initialize to zero</td>
<td>• Arrays initialize to garbage</td>
</tr>
<tr>
<td>• Syntax:</td>
<td>• Syntax: *</td>
</tr>
<tr>
<td>/* comment */</td>
<td>/* comment */</td>
</tr>
<tr>
<td>// comment</td>
<td>// comment</td>
</tr>
<tr>
<td>System.out.print</td>
<td>printf</td>
</tr>
</tbody>
</table>

* You need newer C compilers to allow Java style comments, or just use C99
C Syntax: True or False?

• What evaluates to FALSE in C?
  • 0 (integer)
  • NULL (pointer: more on this later)
  • no such thing as a Boolean*

• What evaluates to TRUE in C?
  • everything else…
  • (same idea as in scheme: only #f is false, everything else is true!)

*Boolean types provided by C99’s stdbool.h
C syntax : flow control

- Within a function, remarkably close to Java constructs in methods (shows its legacy) in terms of flow control
  - if-else
  - switch
  - while and for
  - do-while