# C++ Workshop

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# Background: Workshop Structure

- the C++ you see in classes is very different than the C++ you might see on co-op
- compare/contrast with 2 examples you may have seen in embedded design
- some tools that can help writing C++ programs

general notes:

- ask questions at any time!
- reach out with any lingering questions

# Background: C++

what even is C++?

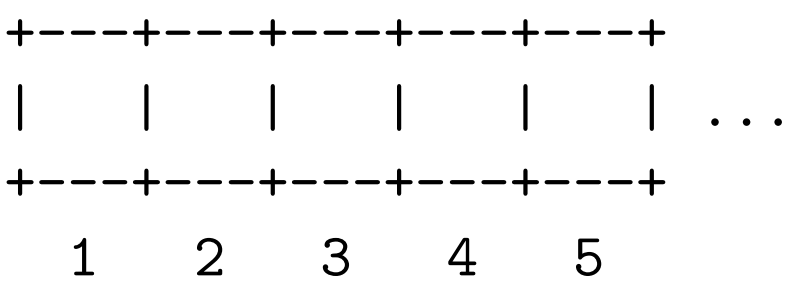
- *compiled*: a *compiler* (`g++`, `clang`) translates human-readable text-files into machine code
- *high-level*: use C or assembly if you want more control
- *old*: new features have been added regularly since 1985

"There are only two kinds of languages: those that people [complain] about and those that nobody uses." – Bjarne Stroustrup, `comp.lang.c++`

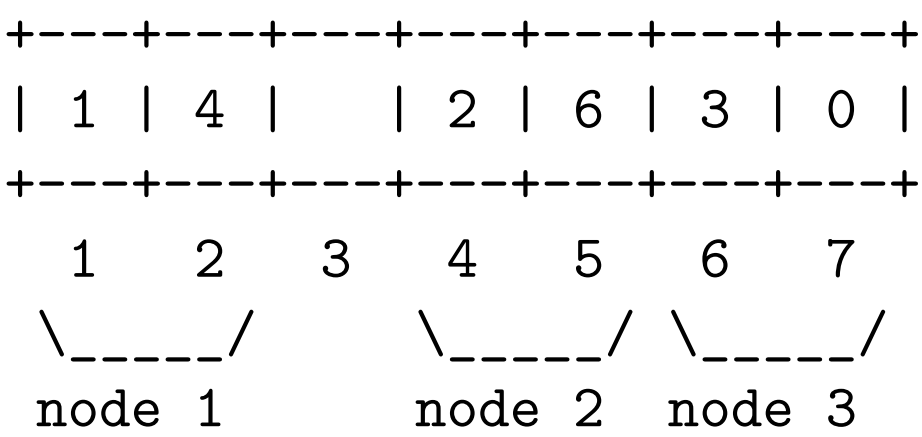
"Within C++, there is a much smaller and cleaner language struggling to get out" – Bjarne Stroustrup, "The Design and Evolutions of C++" [1994]

# Example: Linked Lists – Memory Layout

What does a linked list acutally *look like*? Memory is just a sequence of 'words', each with an 'address':




a *linked list* containing `{1, 2, 3}` might look like:



# Example: Linked Lists – C++, Old-Style

```
class node {
    public:
        int val;
        node *next;
};
```

let's use this...

```
node * n1 = new node(); // memory for 3 nodes...
node * n2 = new node();
node * n3 = new node();
n1->val = 1;            // set up the values...
n1->next = n2;
n2->val = 2;
n2->next = n3;
n3->val = 3;
n3->next = nullptr;     // fin
```

# Example: Linked Lists – C++, Standard Library

```
#include <forward_list>

using std::forward_list;

int main(void) {
    forward_list<int> list;
    list.assign({1, 2, 3});

    return 0;
}
```

- concise, less error-prone
- don't need to worry about the internals of the memory representation
- want a doubly-linked list? drop in `list` in place of `forward_list`.

# Example: Memory – Manual

```
void function(void) {
    node * n = new node();
    // do some stuff...
    return;

    // oops, we forgot to delete n.
    // memory leak!
}
```

this `new` and `delete` stuff is annoying. doesn't this seem like something that the compiler should be able to figure out for us?

# Example: Memory – Automated

```
void function(void) {
    unique_ptr<node> n = new node();
    // do some stuff...
    return;

    // at then end we are leaving this *scope*.
    // the compiler knows to delete n.
}
```

# Tools: Linters (`clang-check`)

a 'linter' looks at the text of your program (i.e. doesn't actually *run* it), and flags potential issues

- syntactic issues: forgot a semicolon, etc.
- semantic issues: unfreed memory, types of arugments, etc.

## Syntax

```
std::cout << fib(22) << std::endl

// "expected ';' after expression line 2"
```

## Semantics

```
int * a = new int;
*a = 2;

// "Potential leak of memory pointed to by 'a'"
```

# Tools: Formatter (clang-format)

- re-formats your program for consistency
- helpful to agree on conventions when working with a team

some inconsistent code:

```
int ii=0;
for(ii=0; ii<     10; ii++)
{
if(ii%2 ==1) std::cout << ii; }
```

using clang-format:

```
int ii = 0;
for (ii = 0; ii < 10; ii++) {
    if (ii % 2 == 1) {
        std::cout << ii;
    }
}
```

# Tools: Building

C++ is a *specification*; there are multiple compilers that *implement* that specification: `g++`, `clang++`, etc.

compilers have a lot of options to help you!

- *warnings*: diagnostics from the compiler itself
  - `-Wall`, `-Wextra`, `-Werror`, `-pedantic`, `-Wno-*`, etc.
- *optimization*: what are you optimizing for?
  - `-pipe`, `-DNDEBUG`, `-O2`, `-Os`, etc.
- *standards*: are features available?
  - `-std=c++13`

# Tools: Debugging

## Valgrind

hooks into executing program and notes memory usage. can be used more generally as a profiler.

```
$ valgrind \
        --leak-check=full \
        --show-leak-kinds=all \
        --track-origins=yes \
        --trace-children=yes \
        --show-reachable=no \
        [your compiled program]
```

## GDB

interactive debugger. can be esoteric to use, but extremely useful for runtime debugging.