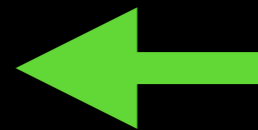


An Introduction to Emscripten

Running C/C++ in a web browser!

Slides available at:
<http://bit.ly/dllemnt1>

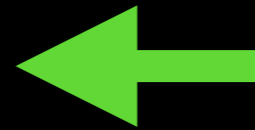


Presented by

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- 15+ years C/C++ experience, largely in games
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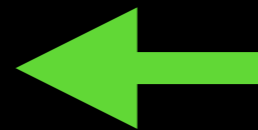
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To be reviewed...

- What is Emscripten?
- What can it do?
- Live Demos
- Installation
- Example Code
- Caveats

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What is Emscripten?

Emscripten is a compiler, toolchain, and runtime library for running C and C++ code in web browsers (or Node.js), without plugins.

(This talk will focus mainly on code run within a web browser.)

What is Emscripten?

- it is a C/C++ compiler and toolchain
 - Clang-backed by default
 - also accepts LLVM byte code as input
- Outputs:
 - JavaScript
 - WebAssembly (a newer, smaller format)
- it offers a runtime, with C and C++ APIs to help work with web browsers (or NodeJS)
- has many limitations over popular, 'native', C/C++ platforms, however many things are possible (and demonstratable)

Demo Time

Qt

[http://example.qt.io/qt-webassembly/Slate/
slate.html](http://example.qt.io/qt-webassembly/Slate/slate.html)

Usable Libraries + APIs

(among others)

- stdio (printf, fopen, ...), iostreams (std::cout, std::fstream, ...)
- POSIX-style file system APIs (opendir, readdir, stat, ...)
 - no std::filesystem, yet
- graphics: OpenGL ES 2+, HTML DOM, LibSDL, ...
- audio: OpenAL, LibSDL, ...
- input (via events): keyboards, mice, touch-screen, game controllers
- partial support for sockets (via WebSockets)

Installation

- instructions at https://emscripten.org/docs/getting_started
- Option 1: Emscripten SDK (aka, “emsdk”)
 - capable of installing and updating many, but not all, dependency technologies
 - works on Windows, Linux, and macOS (at least)
- Option 2: via a 3rd-party package manager
 - HomeBrew (aka. “brew”), for macOS: <https://brew.sh>
 - apt-get, for Ubuntu, Debian (at least)

Basic Usage

“emcc” and “em++”

- similar to other, popular compiler commands
 - (i.e. gcc/g++, clang/clang++, ...)
- Examples:
 - **em++ A.cpp -o A.html**
 - **em++ B.cpp C.cpp -o BC.js**
 - **em++ D.cpp -o D.o**
em++ E.cpp -o E.o
em++ D.o E.o -o DE.js
 - **em++ F.cpp -o F.html -s USE_SDL=2**

Example #1

Hello World, printf edition

```
// Compile with: em++ hello_world.cpp -o hello_world.html
```

```
#include <stdio.h>
```

```
int main() {
```

```
    const char * greeting = "Hello World";
```

```
    printf("%s\n", greeting);
```

```
}
```

Example #2

Hello 42, inline JavaScript

```
// Compile with: em++ hello_42.cpp -o hello_42.html
```

```
#include <emscripten.h>
```

```
int main() {
```

```
    int x = 42;
```

```
    EM_ASM({
```

```
        var greeting = 'Hello ' + $0;
```

```
        alert(greeting);
```

```
    }, x);
```

```
}
```

Talking to Web APIs

- *ALL* interaction with system is done through Web APIs (DOM, WebGL, etc.)
- inline JavaScript
 - very low-level data-interop is present
- higher level libraries
 - Embind — C++11 wrappers
 - wrap JavaScript values as C++ objects
 - wrap C/C++ structs and classes in JavaScript objects
 - call JavaScript functions with C++-style syntax

Example #3

Hello DOM (Document Object Model), via Embind

```
// Compile with: em++ --bind hello_dom.cpp -o hello_dom.js
// Uses a pre-made html file (i.e. "hello_dom.html"), containing the following:
// <div id="my_element"></div>
```

```
#include <emscripten/val.h>
```

```
using namespace emscripten;
```

```
int main() {
```

```
    val my_element = val::global("document").call<val>(
```

```
        "getElementById", val("my_element")
```

```
    );
```

```
    my_element.set("innerHTML", "Hello DOM!");
```

```
}
```

Demo Time

live-video processing (with CCV)

<https://fta2012.github.io/ccv-js/>

Callbacks

- browsers default to running code in a cooperatively-multitasked, single-threaded environment
 - i.e. ‘while (true) {}’ can lead to the web browser hanging
 - functions may only get a few seconds before the browser takes action
 - this applies to ‘int main() { ... }’
- spawning new threads possible, but often not while sharing memory across threads
- long running programs might need to be broken up into short-running time-slices that run on:
 - periodic time-intervals
 - various notable events (user-input entered, data received, etc.)

Example #4

Long Running Execution

```
#include <emscripten.h>
#include <emscripten/val.h>
#include <string>
using namespace emscripten;

int update_count = 0;
void update() {
    val my_element = val::global("document").call<val>(
        "getElementById", val("my_element")
    );
    my_element.set("innerHTML", std::to_string(++update_count));
}

int main() {
    emscripten_set_main_loop(update, 0, 1);
    // code here will not run (due to last parameter to emscripten_set_main_loop)
}
```

```
// Compile with: em++ --bind long_run.cpp -o long_run.js
// Assumes presense of pre-existing html file,
// "long_run.html", which contains:
// <div id="my_element"></div>
```


Caveats

- thread support often unavailable
 - callbacks may need to be utilized here
 - async IO options are available (on the bright side)
- limited socket support
 - via WebSockets, which are not the same as raw sockets
- step-debugging not fully featured
 - partially-possible (in a web browser, via 'source maps')
 - reading/watching variables still in development (CyberDWARF)

Caveats

- limited library support
 - often due to other caveats (such as threading restrictions)
- keyboard shortcuts may be overridden by web-browser(s)
- setjmp/longjmp not possible, nor any low-level stack manipulations
- slower than native code

Demo Time

in-browser gaming (via Doom 3)

<http://wasm.continuation-labs.com/d3demo/>

The End

- LOTS more info at <https://emscripten.org>
- Your Presenter: David Ludwig
 - Twitter: @DavidLudwig
 - <http://dll.fyi>
- Are there any questions?

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