WebAssembly support for clang-repl

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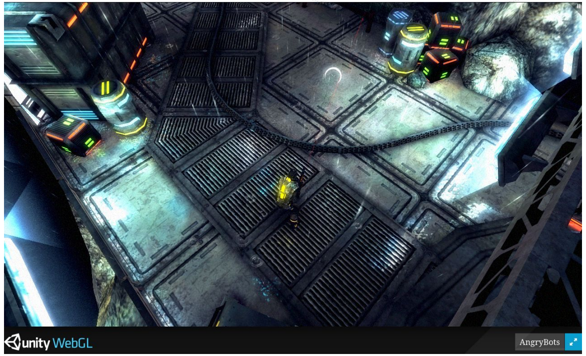
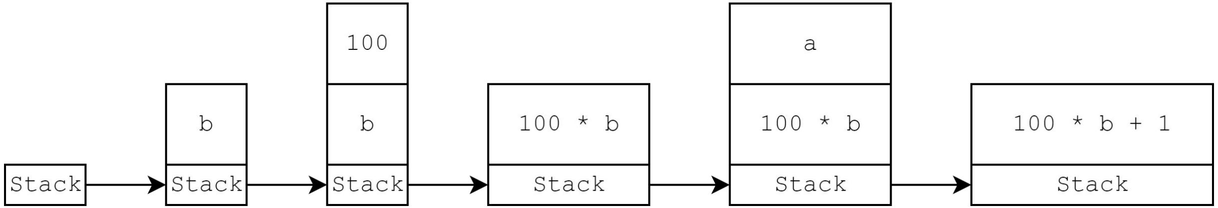
What is Web Assembly?

- Assembly inside a web browser ?!
- Modern Javascript engines rely heavily on JIT compilation of Javascript to native code before execution.
  - There is a trade-off between time to compile vs execution performance improvement.
    - Most engines compile portions of “hot” code after they are executed it several times.
- WebAssembly avoids all of that!
  - Precompiled to an intermediate representation
  - Compact binary representation for fast parsing
  - Simple to execute in an abstract virtual CPU
    - Sandboxed for security and portability
  - Can be easily compiled to native code



How does it actually look like?

- It follows Harvard architecture
  - Instructions and data are strictly separate. Similar to microcontrollers.
  - This has serious consequences for JIT !
- It runs completely sandboxed.
  - By default there is no interface/API for talking to world outside VM.
  - Exports functions that can be called from outside.
  - Imports functions from outside that can be called.
- It is a stack machines.
  - No registers!
  - All computations is performed on the top of the implicit stack.



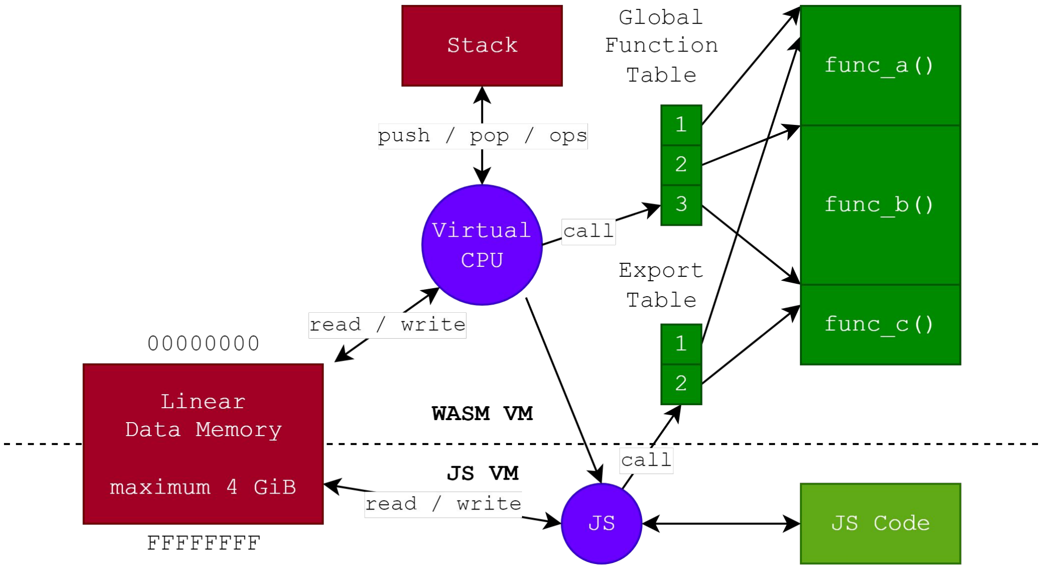

```
func(int, int):
        li      a5,100
        mulw    a5,a5,a1
        addw    a0,a5,a0
        ret
```

```
int func(int a, int b) {
    return b * 100 + a;
}
```

```
func(int, int):
        local.get       1
        i32.const       100
        i32.mul
        local.get       0
        i32.add
        end_function
```

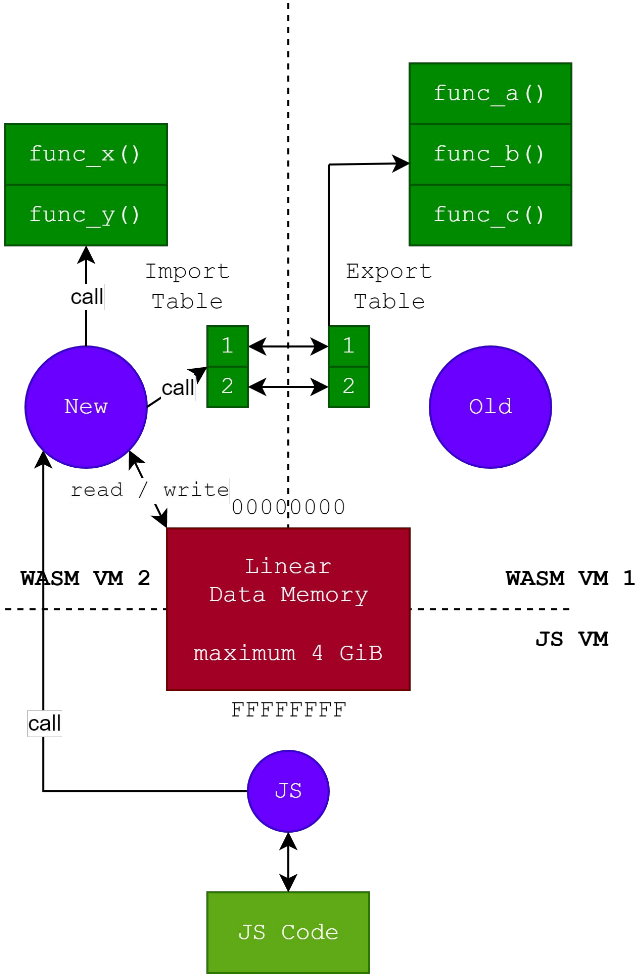
The architecture

- Linear Data memory is accessible from WASM and JS
- Code is divided into variably sized functions
  - The actual internal representation is on the engine
  - WASM code refers to functions by an index which acts like an opaque handle
  - No way to add new functions from WASM code
- No JIT code generation possible from WASM!



Taking help from JS side

- We can generate a new WASM module and give it to the Javascript “runtime”.
- The runtime can instantiate a new WASM Instance with this module.
- Linear memory can be trivially shared between modules.
- Old module can export its functions that the new module imports. Failing that, JS runtime can provide a transparent RPC service.
    - Cross module calls won’t have the best performance.
    - To achieve all of this, we probably have to take most of clang-repl and libInterpreter functionality from C++/WASM into the Javascript runtime.



The Plan

Generate WASM

Produce WASM code in clang-repl.
This should be similar to generating CUDA device code.
We can use the LLVM WebAssembly target.
We skip the execution part and output the generated code.

Inside WASM

Compile Clang for WASM.
Run the JIT within a Javascript engine.
Display the generated code.

Execute

Create full WASM modules within the engine and export it.
Let the JS runtime execute independent bits of code (no linking/shared memory required).

Link

Generate and execute code that depends on previous modules or standard library. This is the trickiest part.

UI

Integrate within JupyterLite.
Possibly provide some convenience functions to use in a notebook?

Thank you