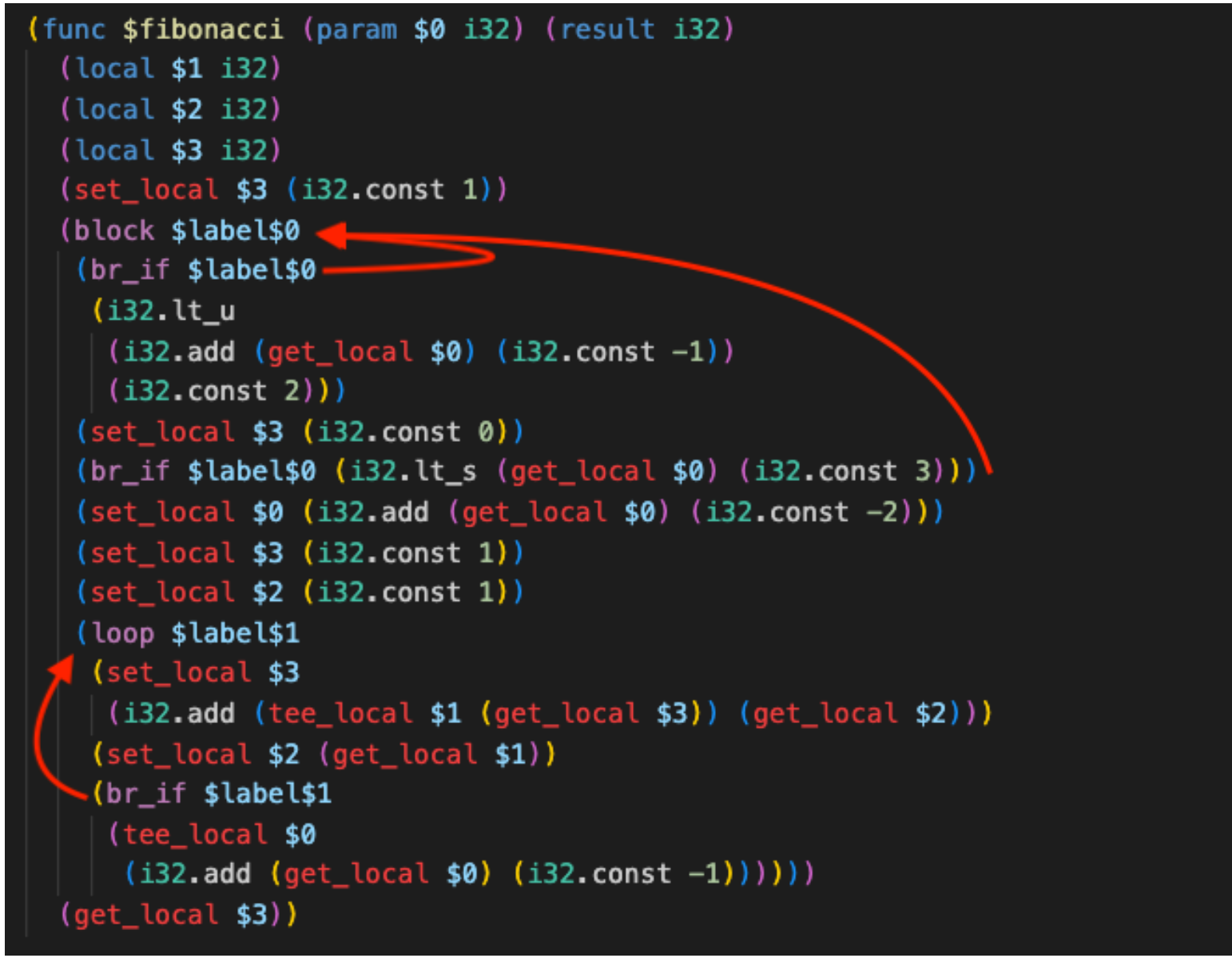
evm2near quick intro

evm bytecode

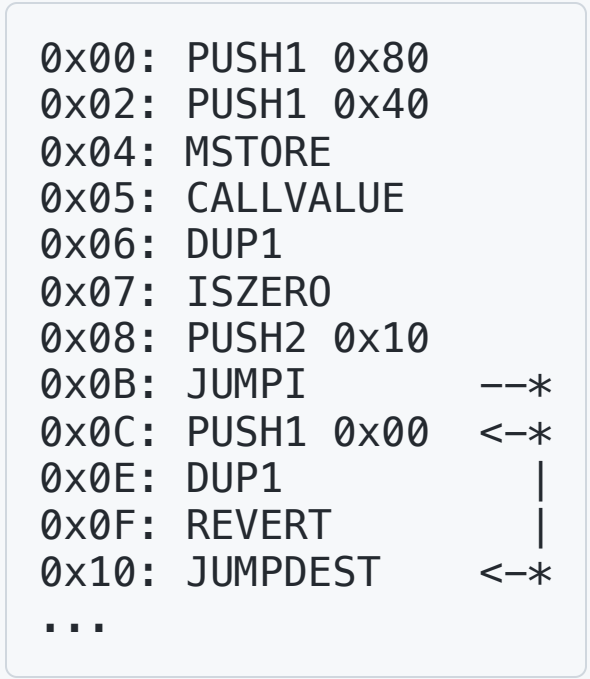
```
0x00: PUSH1 0x80
0x02: PUSH1 0x40
0x04: MSTORE
0x05: CALLVALUE
0x06: DUP1
0x07: ISZERO
0x08: PUSH2 0x10
0x0B: JUMPI       --*
0x0C: PUSH1 0x00  <-*
0x0E: DUP1          |
0x0F: REVERT        |
0x10: JUMPDEST    <-*
0x11: POP
0x12: PUSH1 0x40
...
```

WASM

tries to be similar to programming languages control flow, not other low-level asm/bytecodes



(un)structured control flow

unstructured (any goto-like jump)	structured
	

simplest interpreter

- current position bytecode decoding
- switch statement that chooses appropriate handler and calls it
- handlers for each bytecode operation
    - modifies state
    - returns next bytecode position (to be executed)

translator vs compiler?

- translator
  - converts everything to everything
    - java -> js
    - lisp -> C
    - java bytecode -> .net IL code
    - asm -> native code
    - and even data formats conversion
  - so, compiler is a special case of translator
  - not all translators should be considired compilers
- compiler: source code -> "some executable form":
  - native code (asm <-> native is usually trivially-conversible)
  - VM bytecode (that would be interpreted/JITted/AOT-compiled later)
- **but this is not a rule, and many disagree whether something is a compiler**

what we had at the beginning

sometimes called "interpreter specialized by program":

- we still have "operation handlers" that modify state
- "compiled" program consists of calls to handlers defined by specified evm listing
  - `call(PUSH1)`, `call(DUP2)`, ...
- "handlers" are written in Rust and compiled to wasm module

```
if $I0
  loop $L1
    block $B2
      call $jumpdest
      call $pop
      i32.const 4
      call $push1
      call $calldatasize
      call $lt
      call $_evm_pop_u32
```

what we had at the beginning (part 2)

- due to difference in (un)structured CFG, control flow was implemented naivly:
  - loop is just `call(loop_body)`, so it consumes one stack frame on each iteration
  - to solve that, we needed `relooper`-family algorithm
- overall, it does not differs from interpreted code that much
  - no dispatch code (switch in interpreter case)
  - much more closer to "real compiler", can be gradually improved to be

CFG (control flow graph)

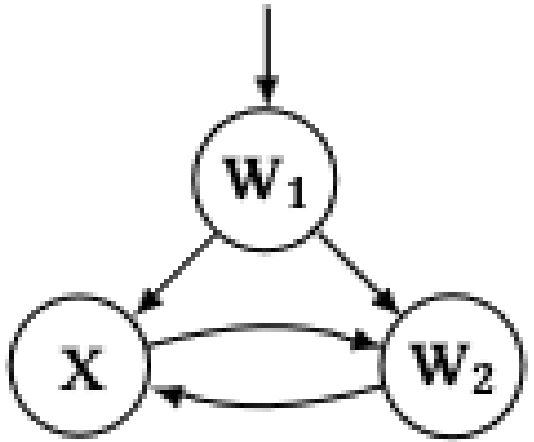
- generated from EVM bytecode
- each node contains set of sequential instructions (basic block)
- edges between nodes -- control flow transfer (`return` , `if` , `loop` , `continue` , `break` + function calls)
- todo image

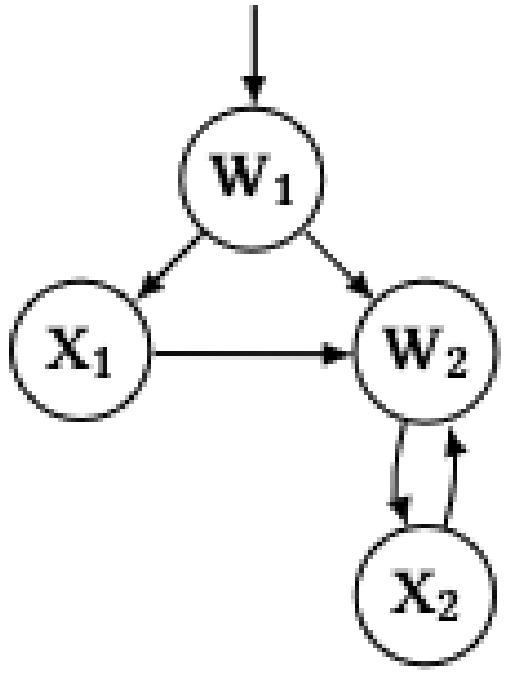
relooper

- transform loops/conditionals to structured CFG
- wasn't needed before wasm that much
- first mention -- Emscripten (C/C++ -> WASM)
  - theory was there since at least late 80
- requires input CFG to be reducible
- we used "Beyond Relooper" by Norman Ramsey (2022)

(ir)reducible loops

- more than one "header" node
- some nodes should be duplicated to "reduce" graph





first approach: supernodes

- proposed by "Beyond Relooper" paper
- series of graph traversal with two actions:
  - merge: merge two nodes to a single `supernode`
  - split: duplicate one node into two, preserving cfg edges
- can produce HUGE graphs (96 initial nodes -> ~5500 output nodes)

second approach: DJ-graphs

- two main papers:
  - "Handling Irreducible Loops: Optimized Node Splitting vs. DJ-Graphs" by Sebastian Unger and Frank Mueller
  - "Identifying Loops Using DJ Graphs" by Vugranam C. Sreedhar, Guang R. Gao, Yong-Fong Lee
- much more complex algorithm
- produces **much** more compact graphs (96 nodes -> 105 output nodes!)
- took months to implement properly

what else?

- huge bunch of algorithms & data structures around graph manupulation in general and CFG specifically
  - traversals, dominators, node orderings, debug-printing, loop detection, heuristics, ...
- evm bytecode analysis rewritten to match new (more complex) CFG structure
- replaced wasm decode & encode tools (unsupported dependency)
  - `parity-wasm` -> `wasmprinter` + `wasm-encoder` + gule code because WASM ecosystem is garbage
- some kind of CI/CD testing

future work

- switch "operation handlers" to "aurora host functions"
  - depends on `synchronous wasm`
  - would enable cross-contract calls
- move towards "real compiler":
  - rewrite some operation handlers to WASM-native instructions
  - get rid of "virtual EVM stack" and utilize WASM stack directly
    - requires data flow analysis & "register allocation" algorithms
- compiler stabilization (or even having a switch for stable compilation)
- multiple-file compilation model
- function splitting (no matter how many function there are, they are represented by single linear EVM listing)
- of cource, much more testing (we havent even tested memory operations properly!)