

HXCPP

HAXE GIRT BY C++

GIRT

Australians all let us rejoice
For we are young and free
We've golden soil and wealth for toil,
Our home is girt by sea

From *Australian National Anthem*

THINGS TO COVER

- The overall architecture
- Some gory implementation details
- Future developments

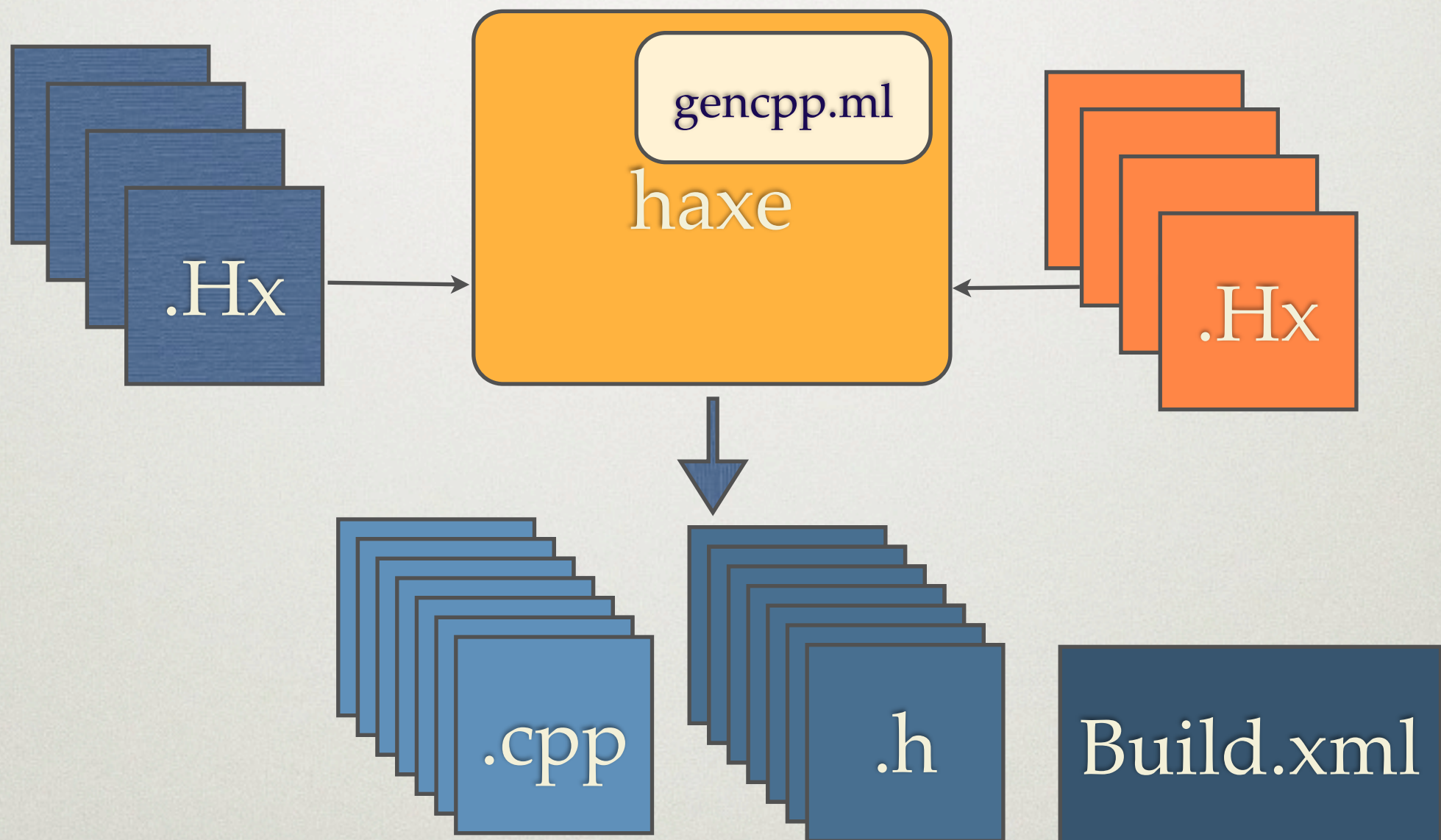
WHY HXCPP?

- The original motivation was speed.
- The neko vm design is very nice, but just too slow for numeric algorithms.
- Currently, for gaming style algorithms:
 - 10x neko
 - 2-3x flash / v8
 - 0.5x hand-written native

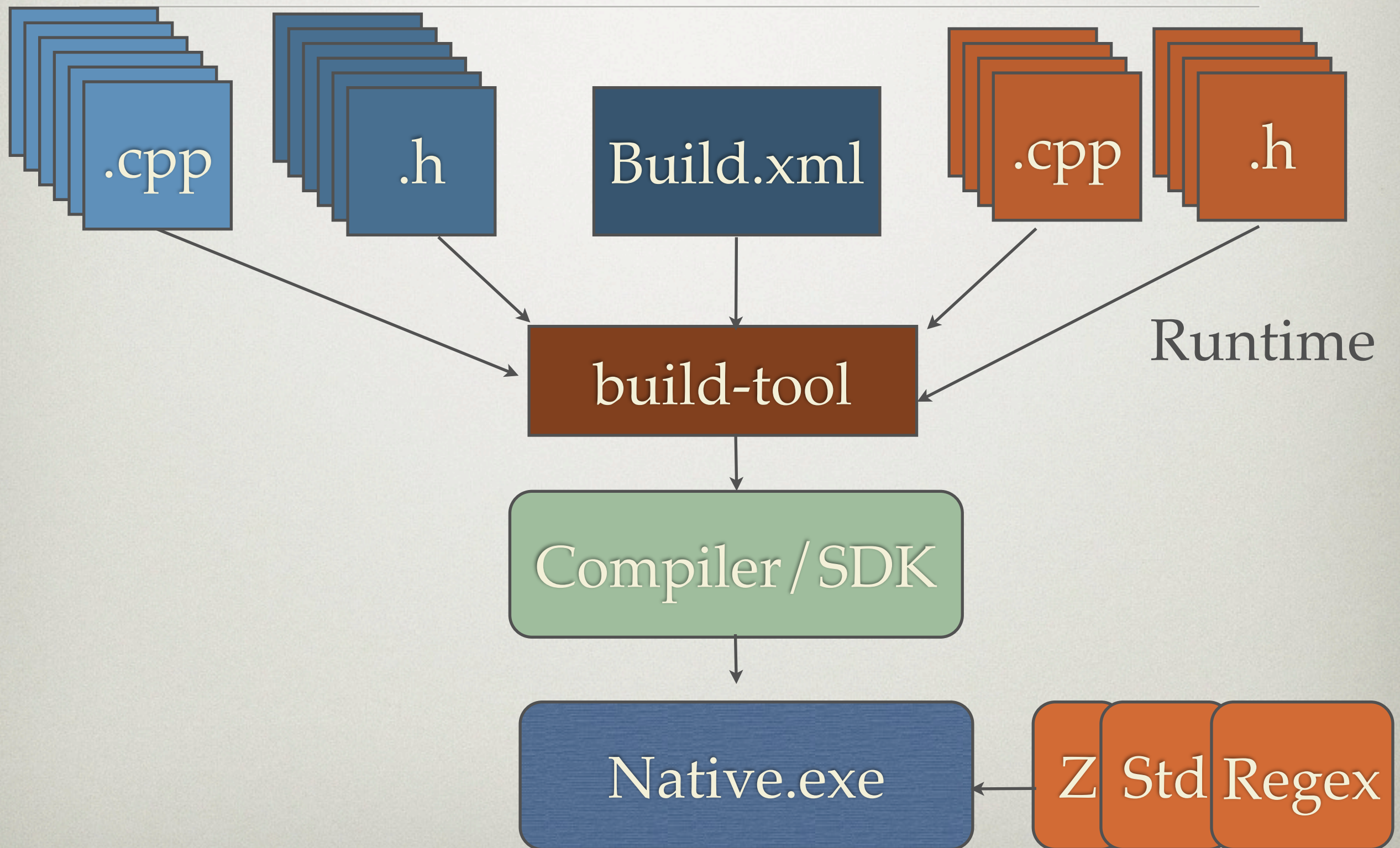
HXCPP IN HAXE

User Code

Library Code



HXCPP IN HAXELIB



GENCPP.ML

- The haXe compiler is written in ocaml, a functional language
- Each "backend" is implemented in a single file
- Gencpp is about 3000 lines of code
- I gained most of my ocaml knowledge from the existing haXe compiler code base
- I probably speak ocaml with a French accent
- Has evolved well beyond initial design

[gencpp.ml](#)

THE .HX LIBRARY FILES

- More than a passing resemblance to the neko library files
- Laziness is a virtue
- Use “compiler magic” to delegate the work to the runtime files



HXCPP OUTPUT

- “Readable” C++ (not c++11)
 - local functions are a bit hairy
- C++ native virtual functions
- C++ native RTTI
- C++ native exceptions
- Templates do “casting” work
- Macros allow a lot of development to be done in C++, not ocaml -> more accessible



THE HXCPP RUNTIME FILES

- Are provided as *source*, not binary
- Good: debugging, tinkering, identical compiler, no binary distribution
- Bad: extra compile time (maybe solved by compiler cache?)
- Includes: Initialisation, Arrays, Dates, Reflection, Strings, Garbage Collection, CFFI, Threading, Math, Debug etc, etc.



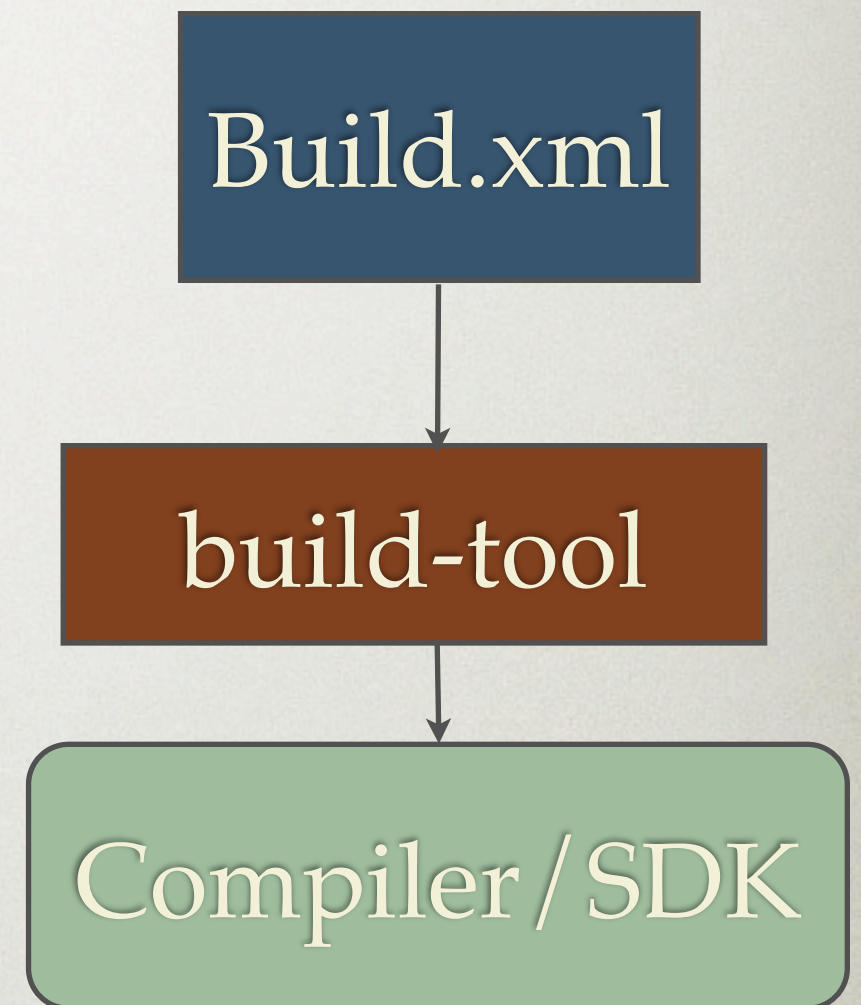
HXCPP RUNTIME DLLS

- Binary distribution
(but source included)
- Also have more than a passing
resemblance to neko ndlls
- Could not use the neko binaries, but
can get a lot of help from source code
- Laziness is still a virtue



BUILD SYSTEM

- Neko based replacement for “make” / “ant”, without cross platform pain
- Very easy to extend - got nice user contributions
- android, blackberry, cygwin, gcc, ios (armv6 / armv7 / i386), linux, mac, mingw, msvc, webos



IMPLEMENTATION

THE LESS NERDY AMONGST YOU MAY WANT TO
POWER DOWN TO SAVE SOME BATTERIES...

STRONG TYPING

- HXCPP gets its speed from strong typing
- I don't mean hitting the keyboard hard
- When the compiler knows a type, it can use registers and perform optimization
- It would be easy just to make everything "Dynamic", but performance would suffer
- Laziness is not a virtue
- Knowing what HXCPP does with certain types is a key to writing high performance code

TYPING CONCEPTS

- **Dynamic** - when i refer to variables as Dynamic, I mean members are identified by name only, rather than ordinal structure position or vtable position. All values can be represented by Dynamic.
- **Boxing** - when a non-class variable (Bool, Int, Float, String) is treated as Dynamic, a “boxing” class must be allocated to provide the Dynamic access. This allocation can be expensive.

WHERE IS DYNAMIC USED?

- `SomeClass<T>` - T variables are stored and arguments are passed as `Dynamic` (what else could they be?)
 - Can use `haxe.rtti.Generic` to create multiple types
 - Create `Bool`, `Int`, `Float`, `String` (just `Float`) variations?
- Functions stored in variables (closures)
 - Have strongly typed functor classes (blowout ?), or just `Float` variations?
- `function foo(bar:{run:Void->Void})`
 - Fake interfaces?
- `var bar = { x : 20 }`
 - Fake classes?

ARRAYS

- Arrays are strongly typed, and have natural C++ implementation
- Are fast - except they have a range check on every access
- Can even avoid this with “unsafe” access
- `Array<Dynamic>` is actually `Dynamic`, so it can cope with both `Array<Bool>` and `Array<SomeClass>`

INTERFACES

- Originally, I used C++ virtual & multiple inheritance. This was going to cause problems with GC due to vtable offset thunks
- Changed to use delegation (interface object has a pointer to original object) - everything was much nicer
- Variables in interfaces are treated with get/set functions. I considered using references, but it was technically challenging

LONG OUTSTANDING ISSUE

- C++ allows some flexibility in the order of some calculations
- Nice to optimizing compilers
- Nasty for deterministic results
- Because of the way arguments are pushed on the stack, the most efficient order for calculation is right-to-left :(
- Working around this has daunted me:
`x = (i++) ? b++ : f(c++ || i++, i++)`

CFFI

- C Foreign Functional Interface (actually, C++ FFI)
- Dynamic libraries (static for iPhone) can be built externally and then used. The HXCPP build tool is good for this.
- CFFI allows external code to interact with HXCPP objects by treating them as "handles"
 - This is VM implementation independent to a large extent (can use the same ndll for neko,v8,cpp ...)
- Boxing issues (looking at Float variations)
- Some care must be taken with garbage collection and blocking operations - make porting neko ndlls harder

METADATA MAGIC

- You can inject code into your classes to call “normal” C++ code.
- Because HXCPP uses natural C++, passing and converting types is quite easy
- May be easier in some cases than CFFI
- Or, maybe get you out of trouble, or get maximum speed (eg, raw function pointers)
- Newer development, but HXCPP is starting to use it for the runtime calls

GARBAGE COLLECTION(GC)

- HXCPP has built-in GC, with minimal assumptions:
 1. a standard stack layout,
 2. registers can be forced on the stack with a sufficiently complex function call.
- So far, so good!!
- The collection is “mostly precise”, where the haxe objects are marked precisely, but the stack is also scanned conservatively
- This allows objects to be found in CFFI routines, and optimised code.

...GARBAGE COLLECTION

- All allocating threads need to cooperate with GC
- The compiler creates routines to do the mark phase - there may be some optimisations that can be done here
- The code is pretty simple - and compiles easily on all targets
- There is plenty of scope for research + optimization

FUTURE

I NEVER THINK OF THE FUTURE - IT COMES SOON
ENOUGH. ~ALBERT EINSTEIN

FUTURE

- Work is ongoing to support haXe features as they are developed
- Add new compilers as required
- Improve performance by making fewer things “Dynamic” (probably in order of importance)
 - function variables -> full or partial typing
 - numeric versions of template classes
 - anonymous structs -> fake classes
 - type restrictions -> fake interfaces

...FUTURE

- Improve Garbage Collection speed
 - multi-thread the mark / collection
 - defragmentation / moving
 - revisit marking strategy
- Would be a good project for someone interested

...FUTURE

- Improve instrumentation in debug mode
 - Integrated socket based debugger
 - Profiling / code coverage metrics
 - Tracing objects for GC
 - Graphical views of memory usage etc. etc.

// COMMENTS?