NativeBoost

Igor Stasenko

May, 2012

Pharo Conf

What is NativeBoost?

- A plugin for VM which allows you to run machine code generated in image
- A set of utilities at language side which helping you to generate machine code and interact with VM
- It is more a philosophy than technology

A philosophy

- **ALL** interesting stuff should happen at language side
- No need to recompile VM each time you need to change something
- You should be able to ship your code in smalltalk. And it should work out of the box.

How does it works

- We’re extending a CompiledMethod trailer to carry a native code
- All native code is invoked via single primitive, provided by NativeBoost plugin: #primitiveNativeCall

```
someMethod: x y: y z: z
    <primitive: #primitiveNativeCall
        module: #NativeBoostPlugin>
        ...
```

Project components

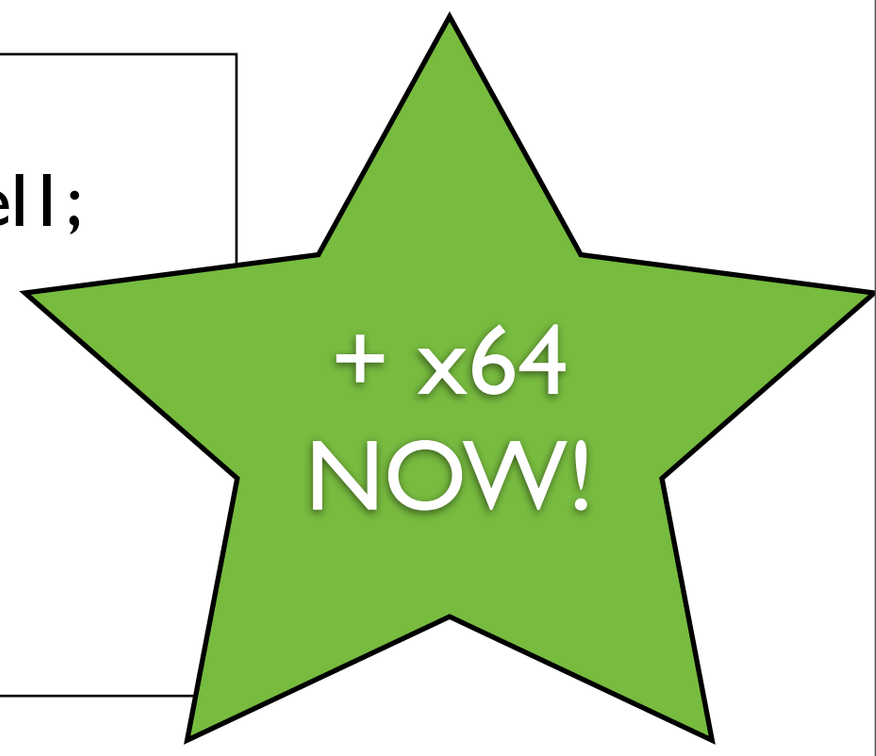
- AsmJit - an assembler
- NativeBoost-Core - the core implementation
- NativeBoost-Unix/Mac/Win32 - a platform-specific support code
- Tests
- Examples

AsmJit - a simple assembler

```
| asm |
asm := AJx86Assembler new.
asm
    push: asm EBP;
    mov: asm ESP -> asm EBP;
    mov: 1024 -> asm EAX;
    mov: asm EBP -> asm ESP;
    pop: asm EBP;
    ret;
    bytes.
```

```
    asm
        mov: EAX ptr - 1 -> EAX;
        mov: EBX ptr + ECX * 2 - 5 -> EAX.
```

```
    asm
        label: #label1;
        nop;
        nop;
        nop;
        jz: #label1.
```



an x86 assembler as it is (just in smalltalk ;)

NativeBoost-Core

- A top-level interface (NativeBoost class)
- VM interface (NBInterpreterProxy)
- FFI callout interface (NBFFICallout)
- C argument(s)/return type marshaling (NativeBoost-Core-Types)
- interface for generating native functions: NBNativeFunctionGen

NativeBoost interface

- contains code for bootstrapping a NativeBoost on target platform
- provides a default interface for external memory management (#alloc: / #free:)
- provides a default interface for loading external libraries and looking up their symbols
- subclasses taking care about platform-specific nuances

NBInterpreterProxy

- InterpreterProxy is a table of functions pointers - a public API of VM (sqVirtualMachine.h/.c)
- NBInterpreterProxy main purpose is interacting with VM: retrieving method's arguments, accessing object's state etc
- some VM functions may trigger GC, therefore we have a limitation: generated native code should be relocation agnostic

NBFFICallout

- responsible for generating a machine code to make foreign calls
- support for different calling conventions (currently - cdecl and stdcall)
- provides a simple default interface for making foreign calls

First foreign call

man getenv ...

NAME

getenv, putenv, setenv, unsetenv -- environment variable functions

LIBRARY

Standard C Library (libc, -lc)

SYNOPSIS

```
#include <stdlib.h>

char *
getenv(const char *name);
```

RETURN VALUES

The getenv() function returns the value of the environment variable as a NUL-terminated string. If the variable name is not in the current environment, NULL is returned.

Calling getenv...

```
getEnv: name

    <primitive: #primitiveNativeCall
module: #NativeBoostPlugin error: errorCode>

^ self nbCall: #(
        String getenv( String name)
    ) module: NativeBoost CLibrary
```

The magic

- initially, a compiled method is just a method with primitive
- on a first call a primitive fails, leading to entering a method body
- NBFFICallout then generating machine code, installs it into caller’s method and retry the message send
- machine code embedded into a method => its life cycle same as method where its installed

Forming a foreign call in detail

```
getEnv: name
        <primitive: #primitiveNativeCall module: #NativeBoostPlugin>

    ^ NBFFICallout cdecl: #(

            String  getenv ( String name, ... )

    ) module: NativeBoost CLibrary
```

cdecl - call convention
String - return type
getenv - function name
String - argument type
name - argument name

module - the module name or its handle, where to look for a function

Passing arguments

HeapAlloc Function

Allocates a block of memory from a heap. The allocated memory is not movable.

Syntax

```
LPVOID WINAPI HeapAlloc(
  __in  HANDLE hHeap,
  __in  DWORD dwFlags,
  __in  SIZE_T dwBytes
);
```

dwFlags [in]

HEAP_GENERATE_EXCEPTIONS
0x00000004
HEAP_NO_SERIALIZE
0x00000001
HEAP_ZERO_MEMORY
0x00000008

http://msdn.microsoft.com/en-us/library/aa366597%28v=vs.85%29.aspx

Naive approach

```
heapAlloc: aHeap flags: aFlags size: numberOfBytes

<primitive: #primitiveNativeCall module: #NativeBoostPlugin>

    ^ NBFFICallout stdcall: #(
LPVOID HeapAlloc (HANDLE aHeap , DWORD aFlags ,
SIZE_T numberOfBytes))
    module: #Kernel32
```

```
NBWin32Heap>>allocate: numBytes
^ self heapAlloc: heap flags: 0 size: numBytes
```

```
NBWin32Heap>>zalloc: numBytes
^ self heapAlloc: heap flags: HEAP_ZERO_MEMORY size: numBytes
```

Clever approach

```
NBWin32Heap>>alloc: numberOfBytes
	<primitive: #primitiveNativeCall module: #NativeBoostPlugin>

	^ NBFFICallout stdcall: #(

LPVOID HeapAlloc (self , 0 , SIZE_T numberOfBytes)

	) module: #Kernel32
```

```
NBWin32Heap>>zalloc: numberOfBytes
	<primitive: #primitiveNativeCall module: #NativeBoostPlugin>

	^ NBFFICallout stdcall: #(

LPVOID HeapAlloc (self , HEAP_ZERO_MEMORY , SIZE_T numberOfBytes)

	)module: #Kernel32
```

Types

- support for basic C types: int, float etc
- type aliases: map a name to one of the basic types
- C structures (see NBExternalStructure and subclasses)

Custom types

- subclass NBExternalType
- (demonstrate NBUTF8StringExample)

Getting rid of bloat

```
heapAlloc: aHeap flags: aFlags size: numberOfBytes

<primitive: #primitiveNativeCall module: #NativeBoostPlugin>

    ^ self call: #( .... )
```

It’s just a smalltalk code

Examples & Demo

Future plans

- integrate callback mechanism
- support for non-blocking call mode
- integration with JIT

?

The end