

COMP 8551

Advanced Games

Programming

Techniques

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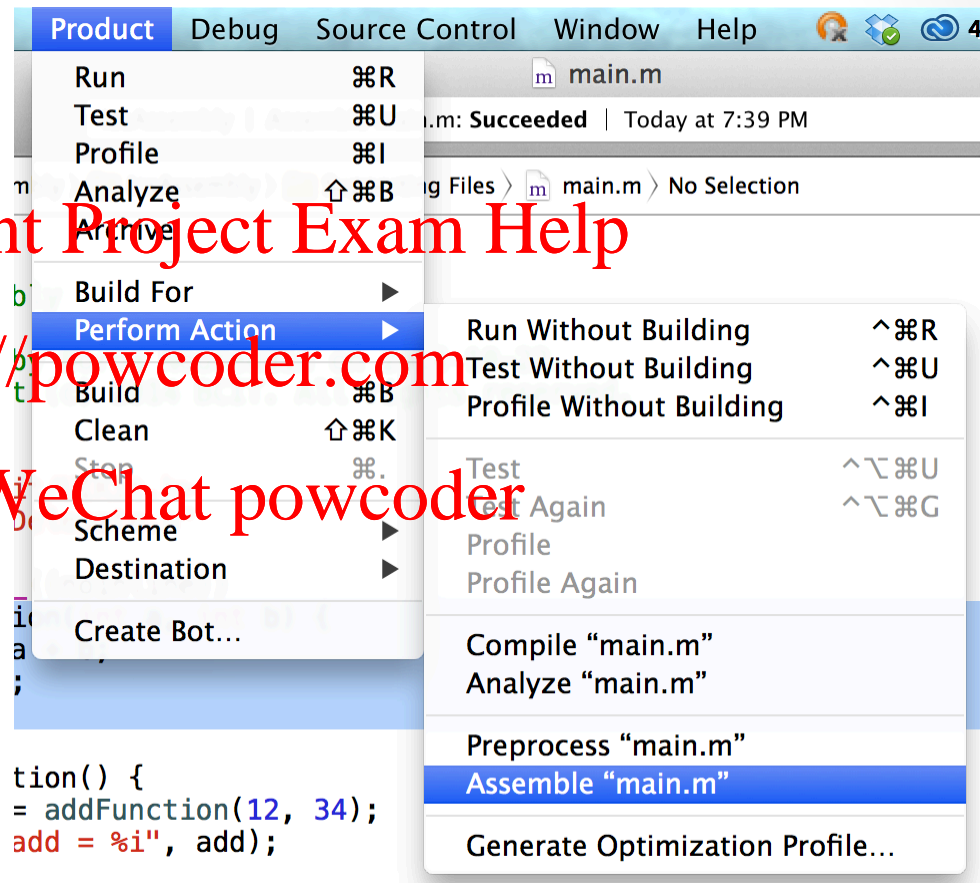
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Assembly Language: ARM/NEON

XCode / ARM example

- ARM = RISC architecture
- Can use XCode to see assembly code
- Can embed in C code



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XCode / ARM example

Registers

- r0 - r3: parameters passed to a function
- r4 - r11: function's local variables
- r12: scratch register
- r13: stack pointer
- r14: link register (address of next instruction to execute when returning from the current function)
- r15: program counter (address of currently executing instruction)

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XCode / ARM example

Registers

- w0 - w3: parameters passed to a function
- w4 - w11: function's local variables
- w12: scratch register
- w13: stack pointer
- w14: link register (address of next instruction to execute when returning from the current function)
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XCode / ARM example

```
int addFunction(int a, int b) {  
    int c = a + b;  
    return c;  
}
```

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What does this simple function look like in
Assembler?

XCode / ARM example

```
_addFunction:                                ; @addFunction
Lfunc_begin0:
/Users/borna/Documents/dev/ios/armneon/armneon/main.m:13:0
    sub    sp, sp, #16                      ; =16
    str    w0, [sp, #12]
    str    w1, [sp, #8]
/Users/borna/Documents/dev/ios/armneon/armneon/main.m:14:13
    ldr    w0, [sp, #12]
/Users/borna/Documents/dev/ios/armneon/armneon/main.m:14:17
    ldr    w1, [sp, #8]
/Users/borna/Documents/dev/ios/armneon/armneon/main.m:14:15
    add     w0, w0, w1
/Users/borna/Documents/dev/ios/armneon/armneon/main.m:14:9
    str    w0, [sp, #4]
/Users/borna/Documents/dev/ios/armneon/armneon/main.m:15:12
    ldr    w0, [sp, #4]
/Users/borna/Documents/dev/ios/armneon/armneon/main.m:15:5
    add     sp, sp, #16                      ; =16
    ret
```

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XCode / ARM example

```
_addFunction:                                ; @addFunction
Lfunc_begin0:
/Users/borna/Documents/dev/ios/armneon/armneon/main.m:13:0
    sub    sp, sp, #16                      ; =16
    str    w0, [sp, #12]
    str    w1, [sp, #8]
/Users/borna/Documents/dev/ios/armneon/armneon/main.m:14:13
    ldr    w0, [sp, #12]
/Users/borna/Documents/dev/ios/armneon/armneon/main.m:14:17
    ldr    w1, [sp, #8]
/Users/borna/Documents/dev/ios/armneon/armneon/main.m:14:15
    add     w0, w0, w1
/Users/borna/Documents/dev/ios/armneon/armneon/main.m:14:9
    str    w0, [sp, #4]
/Users/borna/Documents/dev/ios/armneon/armneon/main.m:15:12
    ldr    w0, [sp, #4]
/Users/borna/Documents/dev/ios/armneon/armneon/main.m:15:5
    add     sp, sp, #16                      ; =16
    ret
```

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XCode / ARM example

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```
0x1000a2768 <+0>: sub    sp, sp, #0x10      ; =0x10
0x1000a276c <+4>: str    w0, [sp, #0xc]
0x1000a2770 <+8>: str    w1, [sp, #0x8]
0x1000a2774 <+12>: ldr    w0, [sp, #0xc]
0x1000a2778 <+16>: ldr    w1, [sp, #0x8]
0x1000a277c <+20>: add    w0, w0, w1
0x1000a2780 <+24>: str    w0, [sp, #0x4]
0x1000a2784 <+28>: ldr    w0, [sp, #0x4]
0x1000a2788 <+32>: add    sp, sp, #0x10      ; =0x10
0x1000a278c <+36>: ret
```


XCode / ARM example

What about calling the function?

```
__attribute__((noinline))  
int addFunction(int a, int b) {  
    int c = a + b;  
    return c;  
}
```

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```
void fooFunction() {  
    int add = addFunction(12, 34);  
    printf("add = %i", add);  
}
```

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XCode / ARM example

```
0x1000ae728 <+0>: sub    sp, sp, #0x20          ; =0x20
0x1000ae72c <+4>: stp     x29, x30, [sp, #0x10]
0x1000ae730 <+8>: add     x29, sp, #0x10          ; =0x10
0x1000ae734 <+12>: orr     w0, w4, #0xc
0x1000ae738 <+16>: mov     w1, #0x22
0x1000ae73c <+20>: bl      0x1000ae700          ; addFunction at main.m:13
```

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XCode / ARM example

```
__attribute__((noinline))
```

```
int add_two_int(int x, int y) {
```

```
    int ret;
```

```
    asm volatile (
```

```
        "add %w[ret], %w[x], %w[y]"
```

```
        // outputs
```

```
        : [ret]"=r"(ret)
```

```
        // inputs
```

```
        : [x]"r"(x), [y]"r"(y)
```

```
    );
```

```
    return ret;
```

```
}
```

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```
sub sp, sp, #16
```

```
str w0, [sp, #12]
```

```
str w1, [sp, #8]
```

```
ldr w0, [sp, #12]
```

```
ldr w1, [sp, #8]
```

```
; InlineAsm Start
```

```
add w0, w0, w1
```

```
; InlineAsm End
```

```
str w0, [sp, #4]
```

```
ldr w0, [sp, #4]
```

```
add sp, sp, #16
```

```
ret
```

XCode / ARM / NEON example

NEON for vectorization:

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<http://www.crickettechnology.com/blog/?p=691>

<https://powcoder.com>

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Additional Reading

<http://www.crickettechnology.com/blog/?p=691>

<http://www.raywenderlich.com/37181/ios-assembly-tutorial>

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<http://www.computernostalgia.net/articles/assembly.htm>

<https://powcoder.com>

http://en.wikipedia.org/wiki/Assembly_language#Current_usage

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<https://software.intel.com/en-us/articles/optimizing-the-rendering-pipeline-of-animated-models-using-the-intel-streaming-simd-extensions>

<http://en.wikipedia.org/wiki/SIMD>

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