Bringing the Full Power of Modern Hardware to the Open Web Platform

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Astounding JavaScript* Performance Improvements

Very efficient code generated by Firefox* JIT

LLVM Bitcode

Emscripten

JavaScript* (asm.js)

Achieving ~ 1.5x native running time via targeting asm.js†, a highly optimizable subset of JavaScript

JavaScript performance is approaching native speeds


Epic* Games Unreal Engine* 3

http://www.unrealengine.com/html5/

Over 1M lines of C/C++ code compiled to JavaScript* by Mozilla* and Epic
Microprocessor Trends – “Free Lunch” is over!

- **Growth** in processor clock rate **halted** around 2005
- **Transistors per processor** continues to **grow exponentially**

But, Moore’s Law continues with a shift to parallelism

†(c) 2013, James Reinders and Jim Jeffers: *Intel® Xeon Phi™ High-Performance Programming*, used with permission.
Parallelism is now Required to Benefit from Moore’s Law

SS: Sequential Scalar  PS: Parallel Scalar  PV: Parallel Vector

Monte Carlo European Options DP

LIBOR Market Model normalized

Higher is better

Open web client platform needs to be on Moore’s Law curve

Optimizing Web Runtimes for Parallelism

- HTML5 runtimes of today are not scalable with number of cores
- Need parallelism for both responsiveness and energy efficiency

Web runtimes need to be parallel end-to-end
Parallel Parsing and Compilation

A Concurrent Trace-based Just-In-Time Compiler for Single-threaded JavaScript

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PESPMA 2009

Bootstrap: 4 threads
Launch: 1 thread

Epic* Citadel* profile on Firefox*

Cycle Breakdown

- js::compile
- gfx::compile
- os::others
- js::parse
- js::others
- browser::others
- os::mem
- js::jitted
- gfx::exec

Background JIT compilers now in Chrome*, Firefox, Internet Explorer*, Safari*
**SIMD – Single Instruction, Multiple Data**

**Scalar Operation**

| A_x | + | B_x | = | C_x |
| A_y | + | B_y | = | C_y |
| A_z | + | B_z | = | C_z |
| A_w | + | B_w | = | C_w |

**SIMD Operation of Vector Length 4†**

\[
\begin{align*}
A_x + B_x &= C_x \\
A_y + B_y &= C_y \\
A_z + B_z &= C_z \\
A_w + B_w &= C_w
\end{align*}
\]

**SIMD operations deliver great performance & power efficiency**

† Intel® Architecture currently has SIMD operations of vector length 4, 8, 16
Bringing SIMD to JavaScript

Collaborators: Intel, Mozilla*, Google*, Microsoft*, ARM*, ...

Authors: Google's John McCutchan and Intel's Peter Jensen

Polyfill API: [https://github.com/johnmcccutchan/ecmascript_simd](https://github.com/johnmcccutchan/ecmascript_simd)
float32x4, int32x4, Float32x4Array, Int32x4Array

```javascript
var a = SIMD.float32x4 (1.0, 2.0, 3.0, 4.0);
var b = SIMD.float32x4 (5.0, 6.0, 7.0, 8.0);
var c = SIMD.float32x4.add (a, b);
```

Constructors: float32x4(x,y,z,w) float32x4.splat(s) float32x4.zero()

Operations: abs, neg, add, sub, mul, div, clamp, min, max, reciprocal, reciprocalSqrt, scale, sqrt, shuffle, shuffleMix, equal, notEqual, lessThan, greaterThan, withX, withY ...

Status: In Firefox* Nightly, prototyped in Chromium*, on IEBlog roadmap£

1st stage approval for inclusion in ES7 by TC39†

function mandelx4(c_re4, c_im4) {
    var z_re4 = c_re4;
    var z_im4 = c_im4;
    var four4 = SIMD.float32x4.splat (4.0);
    var two4 = SIMD.float32x4.splat (2.0);
    var count4 = SIMD.int32x4.splat (0);
    var one4 = SIMD.int32x4.splat (1);

    for (var i = 0; i < max_iterations; ++i) {
        var z_re24 = SIMD.float32x4.mul (z_re4, z_re4);
        var z_im24 = SIMD.float32x4.mul (z_im4, z_im4);

        var mi4 = SIMD.float32x4.lessThanOrEqual (SIMD.float32x4.add (z_re24, z_im24), four4);
        // if all 4 values are greater than 4.0, there's no reason to continue
        if (mi4.signMask === 0x00) {
            break;
        }

        var new_re4 = SIMD.float32x4.sub (z_re24, z_im24);
        var new_im4 = SIMD.float32x4.mul (SIMD.float32x4.mul (two4, z_re4), z_im4);
        z_re4 = SIMD.float32x4.add (c_re4, new_re4);
        z_im4 = SIMD.float32x4.add (c_im4, new_im4);
        count4 = SIMD.int32x4.add (count4, SIMD.int32x4.add (mi4, one4));
    }
    return count4;
}
Combining SIMD and Higher-Level Parallelism

WW: Number of WebWorkers

SIMD speedup is nicely multiplied by WebWorkers†

† Source: Intel® Peter Jensen : https://github.com/PeterJensen/
SIMD.JS demos: http://peterjensen.github.io/idf2014-simd
SIMD Speedups on Chromium*

SIMD x-times faster than non-SIMD

Theoretical speedup limit is 4

- 3rd Generation Intel® Core™ i7 processor (3667U)@ 2.00 GHz, 32-bit, Ubuntu* 13
- 3rd Generation Intel® Core™ i7 processor (3667U)@ 2.00 GHz, 64-bit, Ubuntu* 13
- Intel® Atom™ processor Z3770 @ 1.46GHz, Android* 4.4

Excellent early results while still focused on functionality

SIMD.JS benchmarks: https://github.com/johnmccutchan/ecmascript_simd/tree/master/src/benchmarks
Emscripten now targets SIMD.JS

Emscripten brings native SIMD apps to the open web platform
Toward Perceptual Computing†

Learning & Education  Immersive Collaboration  3D Scanning and Sharing

Gaming  Speech  Out-of-reach Device Input

Devices sense and perceive user actions in a natural way

† Source: Intel® Perceptual Computing SDK: www.intel.com/software/perceptual
3D Cameras Make Perceptual Computing Accessible

Web Application

RGB Stream

Depth Stream

getUserMedia (WebRTC) API

Browser or HTML5 runtime

Media Capture Depth Stream Extensions are in W3C WG†

† W3C Media Capture Depth Stream Extensions: http://w3c.github.io/mediacapture-depth/
Toward Perceptual Web†

† 3D Camera WebRTC Demos, Courtesy of Intel® Ningxin Hu: [https://www.youtube.com/channel/UC3eppo33tlz_EP7NWtZc0jQ](https://www.youtube.com/channel/UC3eppo33tlz_EP7NWtZc0jQ)
Demo Sources: Intel® Ningxin Hu: [https://github.com/huningxin/depth_stream_examples](https://github.com/huningxin/depth_stream_examples)
Web: The Most Viable Cross-Platform Technology Today

Rich Capabilities and Content

Big Data

Social Contextual Crowdsourced Sensors “Things”

Visual, Perceptual, Full HW Access

and the Ubiquitous Application Platform of the Future
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