WebGL:
The Standard, the Practice and the Opportunity

Web3D Conference
August 2012

Agenda and Speakers

- **3D on the Web and the Khronos Ecosystem**
  - Neil Trevett, NVIDIA and Khronos Group President
- **Hands On With WebGL**
  - Ken Russell, Google and WebGL Working Group Chair

Khronos Connects Software to Silicon

- **Khronos APIs define processor acceleration capabilities**
  - Graphics, video, audio, compute, vision and sensor processing

APIs BY the Industry FOR the Industry

- **Khronos standards have strong industry momentum**
  - 100s of man years invested by industry leading experts
  - Shipping on billions of devices and multiple operating systems
- **Khronos is OPEN for any company to join and participate**
  - Standards are truly open – one company, one vote
  - Solid legal and Intellectual Property framework for industry cooperation
  - Khronos membership fees to cover expenses
- **Khronos APIs define core device acceleration functionality**
  - Low-level “Foundation” functionality needed on every platform
  - Rigorous conformance tests for cross-vendor consistency
- **They are FREE**
  - Members agree to not request royalties

Silicon

Software

KHRONOS GROUP

API Standards Evolution

DESKTOP

New API technology first evolves on high-end platforms

MOBILE

Mobile is the new platform for apps innovation. Mobile APIs unlock hardware and conserve battery life

INTEROP, VISION AND SENSORS

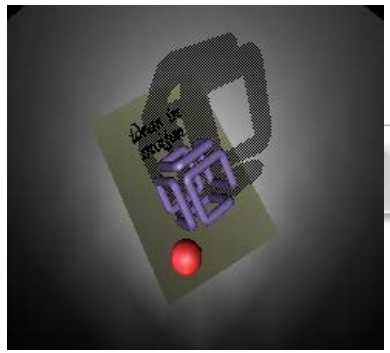
Apps embrace mobility's unique strengths and need complex, interoperating APIs with rich sensory inputs e.g. Augmented Reality

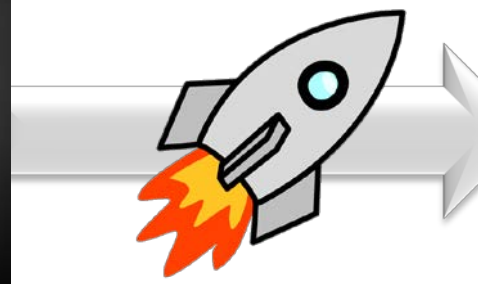
WEB

Diverse platforms – mobile, TV, embedded – mean HTML5 will become increasingly important as a universal app platform

OpenGL 20th Birthday - Then and Now

Ideas in Motion - *SGI*





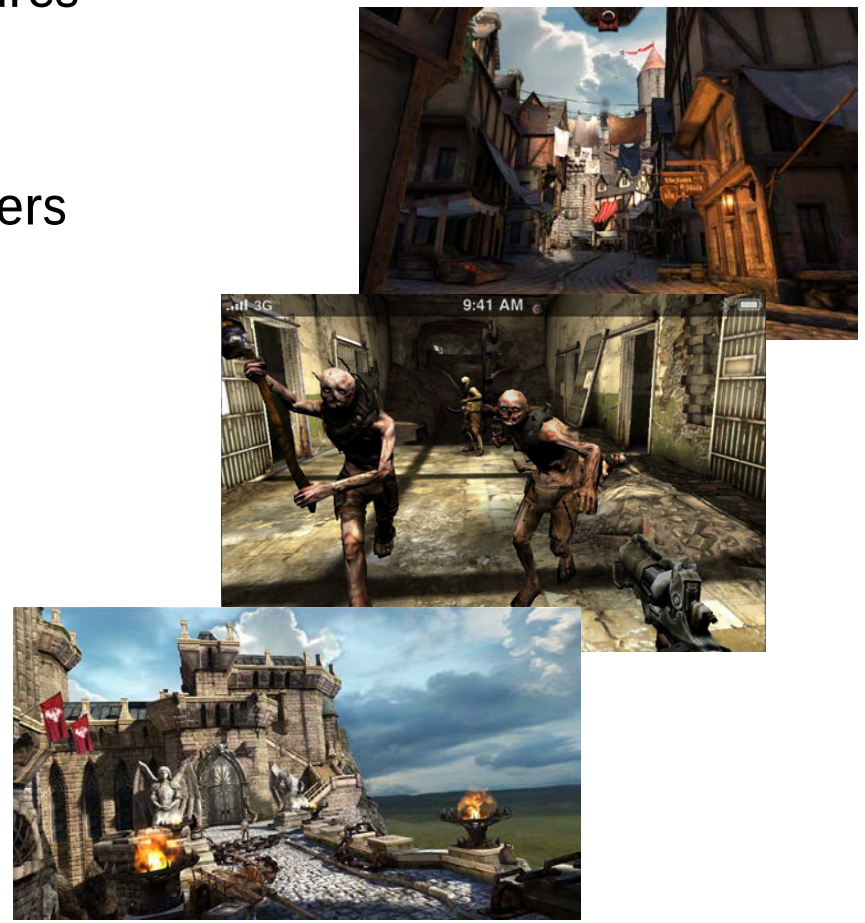
Rage - *id Software*

	1992 Reality Engine 8 Geometry Engines 4 Raster Manager boards	2012 Mobile NVIDIA Tegra 3 Nexus 7 Android Tablet	2012 PC NVIDIA GeForce GTX 680 Kepler GK104
Triangles / sec (millions)	1	103 (x103)	1800 (x1800)
Pixel Fragments / sec (millions)	240	1040 (x4.3)	14,400 (x60)
GigaFLOPS	0.64	15.6 (x25)	3090 (x4830)
	1.5KW	**<5W**	

KHRONOS GROUP

OpenGL ES – Mobile 3D

- **OpenGL for embedded and mobile devices**
  - Eliminates redundant and legacy desktop features
  - Adds mobile-friendly functionality
- **OpenGL ES 2.0 – released March 2007**
  - Fully programmable vertex and fragment shaders
- **The dominant 3D API for mobile devices**
  - Widely adopted for STB, DTV, automotive,...
  - Hundreds and hundreds of millions shipped
- **Runs high-end content and engines**
  - UE3, Unity, Unigine, Rage

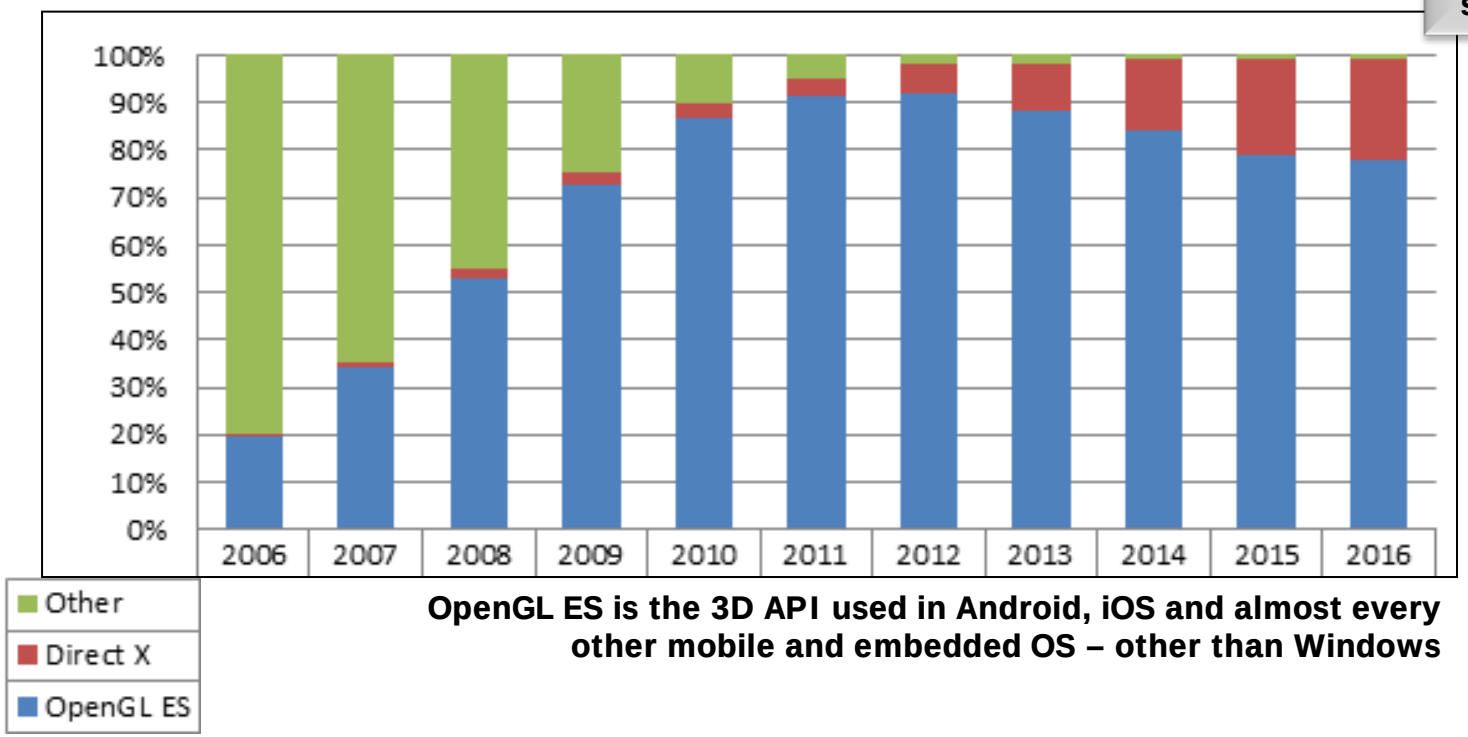


OpenGL|ES™

OpenGL ES Deployment in Mobile

Use of 3D APIs in Mobile Devices

Source: Jon Peddie Research

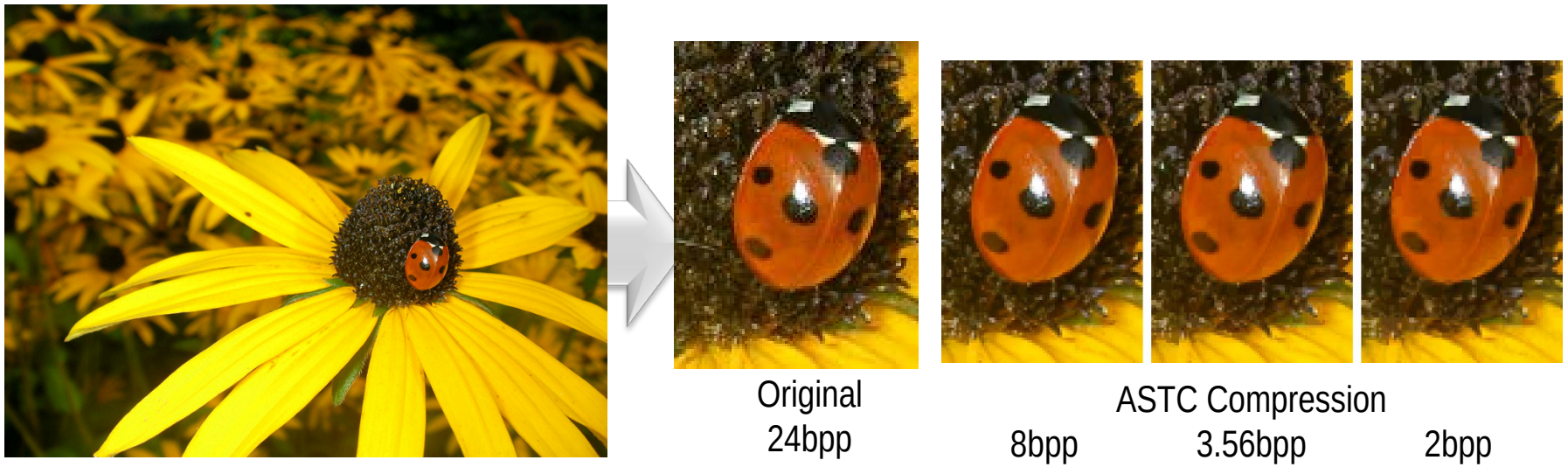


On PC – DirectX is used for most apps. On mobile – the situation is reversed

OpenGL ES is the 3D API used in Android, iOS and almost every other mobile and embedded OS – other than Windows

KHR_compressed_texture_astc_ldr

- **Adaptive Scalable Texture Compression (ASTC) LDR modes**
  - HDR version still being developed
- **1 to 4 color components: R / RG / RGB / RGBA**
  - Developers need low bits per pixel WITH alpha
- **Orthogonal choice of bit rate, from 8 bpp to <1 bpp in fine steps**
  - Quality exceeding S3TC or PVRTC at same bit rate

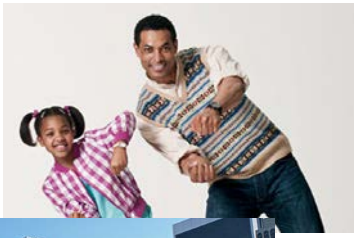


Mobile Platform Innovation

- **New platform capabilities being driven by SILICON and APIs**

Console-Class 3D
Performance, Quality, Controllers and TV connectivity

OpenGL|ES



Vision
Cameras as sensors, Computational Photography, Gesture Processing

Sensor Fusion
Devices become 'magically' context aware – location, usage, position

StreamInput

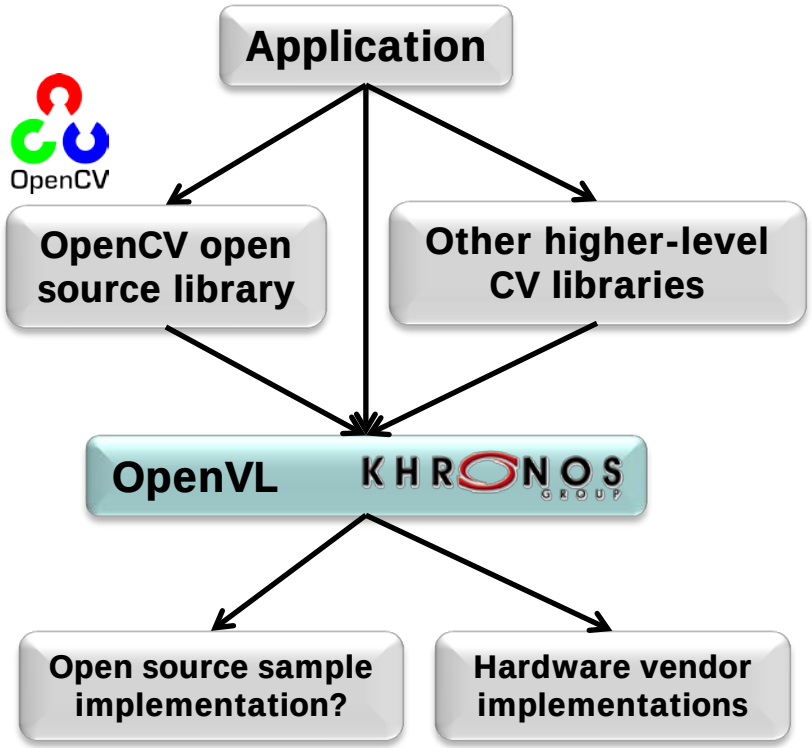
WebGL

HTML5 and WebGL
Web Apps that can be discovered on the Net and run on any platform

KHRONOS GROUP

OpenVL

- **Vision Hardware Acceleration Layer**
  - Enable hardware vendors to implement accelerated imaging and vision algorithms
- **Diversity of efficient implementations**
  - From hardware pipelines to parallel programmable processors
- **Can be used by high-level libraries or applications directly**
  - Primary focus on enabling real-time vision apps on mobile and embedded systems
- **OpenCV is widely used open source library for vision projects**
  - Future versions could leverage OpenVL
  - Do not duplicate OpenCV functionality – JUST provide acceleration



Current OpenVL Participants

- Aiming for specification draft in 2012
- Itseez is working group chair

KHRONOS GROUP

Market Demand for Sensor Fusion API

TODAY

Most platforms expose non-portable APIs with access only to very low-level sensor data (e.g. quaternions for motion)

Every app developer has to be a mathematician and sensor expert

Emerging Sensor Trends

Increasing diversity of sensors available

Apps need to use multiple sensors e.g. camera, motion and touch sensors in mobile

Growing deep knowledge among sensors and middleware vendors how to COMBINE sensor inputs for best quality sensor stream

StreamInput Goals

High-level API to enable sensor FUSION INNOVATION by hardware and middleware vendors UNDER the API

Enable portable applications that do not need to code to sensors on each platform

Motivate non-expert developers to use advanced sensor fusion processing

StreamInput®

Examples of Sensor Fusion

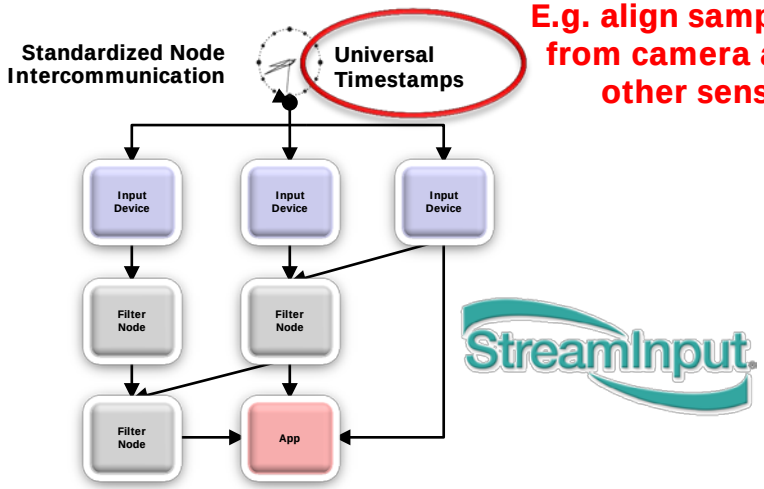
- **Use the accelerometer to ignore environmental magnetic anomalies**
  - Walking through a metal door frame the compass will move but no rotation
- **Use accelerometer to detect vertical motion**
  - Then use relative barometer data to sense how many floors travelled in a elevator for indoor navigation
- **Combine gyro and accelerometer to create high-accuracy, high-frequency positional data stream at low power**
  - Gyro takes a lot of power – but once spinning can be sampled very quickly and accurately (100Hz)
  - Accelerometer is less accurate (20Hz sampling) but take low power
  - Use accelerometer to detect significant motion and THEN power up gyro

- **StreamInput would handle these details – the app developer just requests and receives a high-quality sensor data stream**

Portable Access to Sensor Fusion

Apps request semantic sensor information
StreamInput defines possible requests, e.g.
"Provide Skeleton Position" "Am I in an elevator?"

Advanced Sensors Everywhere
RGB and depth cameras, multi-axis motion/position, touch and gestures, microphones, wireless controllers, haptics keyboards, mice, track pads



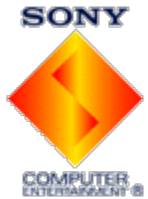
E.g. align samples from camera and other sensors

Apps Need Sophisticated Access to Sensor Data
Without coding to specific sensor hardware

Processing graph provides sensor data stream
Utilizes optimized, smart, sensor middleware
Apps can gain 'magical' situational awareness

Current StreamInput Participants

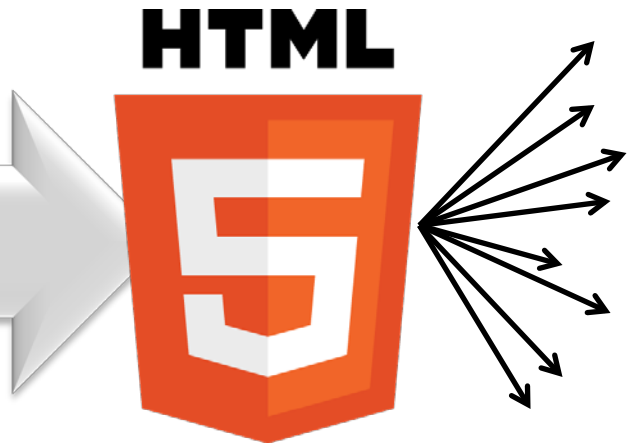
- **Aiming for specification release in 2012**



HTML5 – Cross OS App Platform

- Increasing diversity of devices creates a demand for a true cross OS programming platform
- BUT need more than "more HTML"

Traditional Web-content



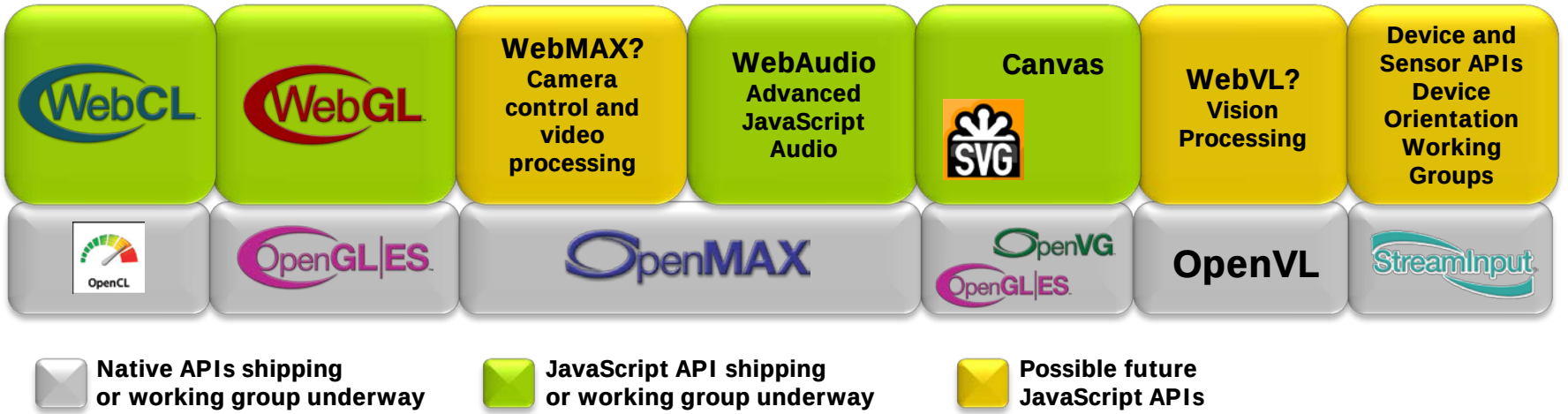
Rich Experiential Processing

Multi-core CPUs
Rich 2D and 3D GPU
GPU Computing
Multiple HD cameras
Image and vision processing
Video encode/decode
Audio encode/decode
Inertial and positional sensors

How can the Browser rapidly assimilate such diverse functionality?

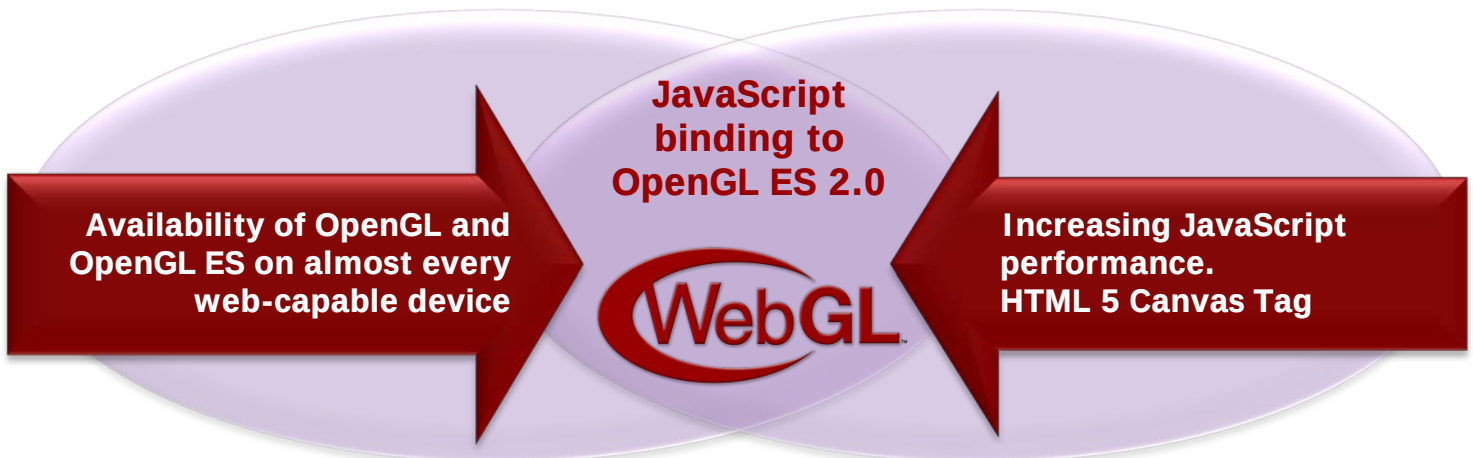
Leveraging Proven Native APIs into HTML5

- **Leverage native API investments into the Web**
  - Faster API development and deployment
  - Familiar foundation reduces developer learning curve
- **Khronos and W3C creating close liaison**
  - Multiple potential joint projects



WebGL – 3D on the Web – No Plug-in!

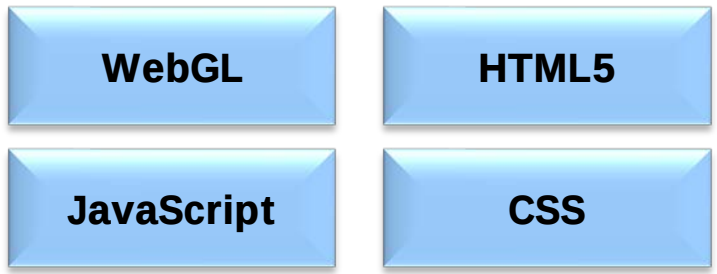
- **Historic opportunity to bring accelerated 3D graphics to web**
  - WebGL defines JavaScript binding to OpenGL ES 2.0
- **Leveraging HTML 5 and uses <canvas> element**
  - Enables a 3D context for the canvas
- **Low-level foundational API for accessing the GPU in HTML5**
  - Flexibility and direct GPU access - support higher-level frameworks and middleware
- **WebGL 1.0 Released at GDC March 2011**
  - Mozilla, Apple, Google and Opera working closely with GPU vendors



WebGL Implementation Anatomy

Content downloaded from the Web. Middleware can make WebGL accessible to non-expert 3D programmers

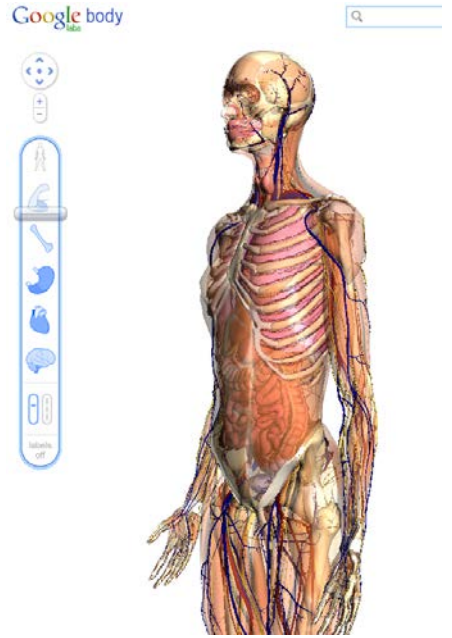
Browser provides WebGL functionality alongside other HTML5 specs - no plug-in required

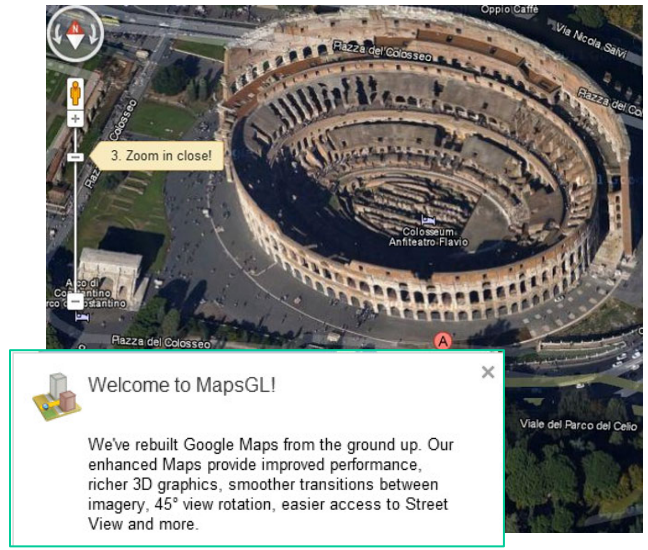


OS Provided Drivers. WebGL on Windows can use Google Angle to create conformant OpenGL ES 2.0 over DX9

Rich WebGL / HTML Interaction

- **3D is not trapped in a rectangular window**
  - 3D can overlay and underlay HTML content
  - Easy to make 2D HTML HUDs or 3D user interfaces
- **Strong ties with other advanced HTML5**
  - WebGL can use HTML5 <video>
    or canvas as a texture
- **Render HTML DOM sub-tree as WebGL texture**
  - Mozilla and Google prototyping as extension
  - Supports user interaction when pages in 3D

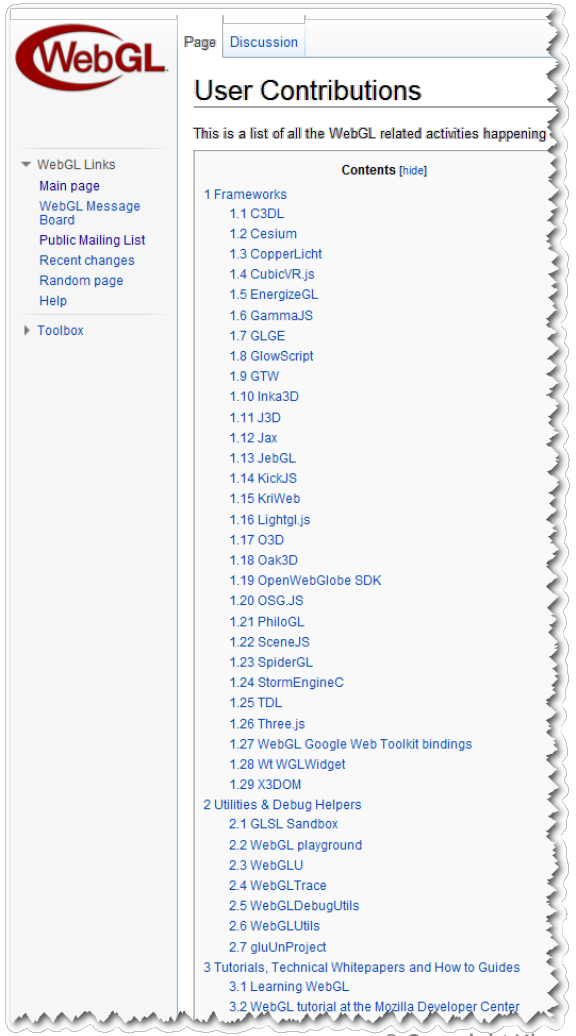




Frameworks and Tools

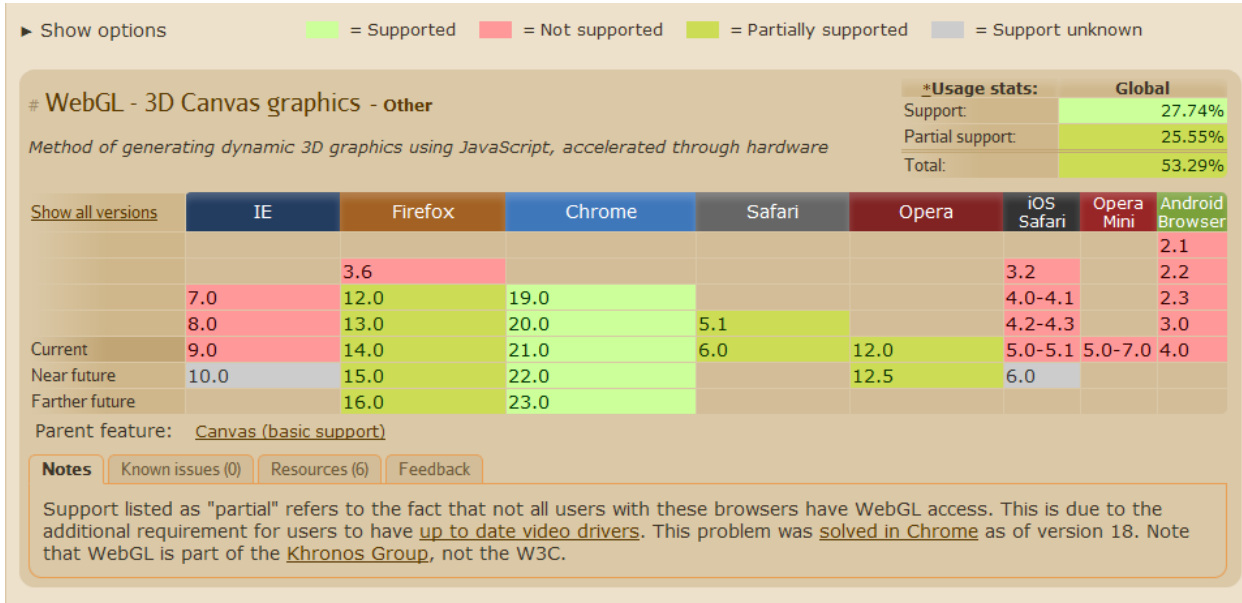
- **WebGL is deliberately low level to enable the full power and flexibility of OpenGL ES 2.0**
- **If you are not an expert 3D programmer – don't panic!**
- **WebGL is perfect foundational layer for JavaScript middleware frameworks**
- **Lots of utilities and tools available**

http://www.khronos.org/webgl/wiki/User_Contributions



WebGL Deployment

- **WebGL 1.0 Released at GDC March 2011**
  - Mozilla, Apple, Google and Opera working closely with GPU vendors
- **IE can be enabled with Chrome Frame**
  - https://developers.google.com/chrome/chrome-frame/
- **Mobile WebGL beginning to ship – Firefox, Opera**
  - Pervasive mobile WebGL expected during next 12 months



► Show options = Supported = Not supported = Partially supported = Support unknown

WebGL - 3D Canvas graphics - Other

Method of generating dynamic 3D graphics using JavaScript, accelerated through hardware

*Usage stats:	Global
Support:	27.74%
Partial support:	25.55%
Total:	53.29%

Show all versions	IE	Firefox	Chrome	Safari	Opera	iOS Safari	Opera Mini	Android Browser
								2.1
		3.6				3.2		2.2
	7.0	12.0	19.0			4.0-4.1		2.3
	8.0	13.0	20.0	5.1		4.2-4.3		3.0
Current	9.0	14.0	21.0	6.0	12.0	5.0-5.1	5.0-7.0	4.0
Near future	10.0	15.0	22.0		12.5	6.0		
Farther future		16.0	23.0					

Parent feature: Canvas (basic support)

Notes | Known issues (0) | Resources (6) | Feedback

Support listed as "partial" refers to the fact that not all users with these browsers have WebGL access. This is due to the additional requirement for users to have up to date video drivers. This problem was solved in Chrome as of version 18. Note that WebGL is part of the Khronos Group, not the W3C.

http://caniuse.com/#search=webgl

WebGL is not enabled by default in desktop Safari.
On iOS 5 WebGL is available to iAds

WebGL and Security

- **WebGL is Architecturally Secure**
  - NO known WebGL security issues
  - Impossible to access out-of-bounds or uninitialized memory
  - Use of cross-origin images are blocked without permission through CORS
  - Browsers maintaining black lists - used if unavoidable GPU driver bugs discovered
- **DoS attacks and GPU hardening**
  - Draw commands can run for a long time -> unresponsive system
    - Even without loops in shaders
  - WebGL working closely with GPU vendors to categorically fix this
  - Short term: mandate ARB_robustness and associated GPU watchdog timer
  - Longer term: GPU provides increasingly robust security and multi-tasking

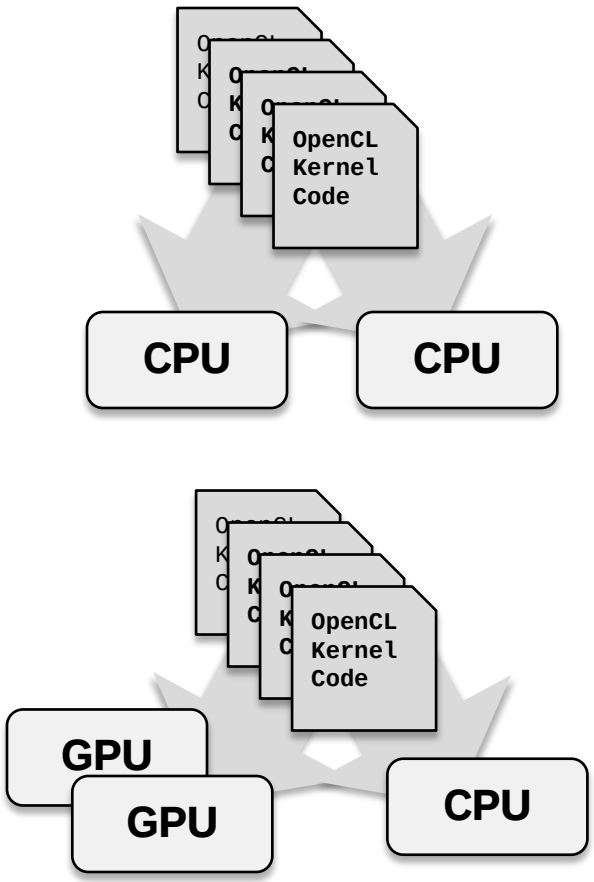
Why Khronos for WebGL?

- **Unique forum where browser and GPU vendors can cooperate**
  - Strong synergy from having both communities under in one organization
- **Opened Khronos process to enable cooperation with web community**
  - http://www.khronos.org/webgl/public-mailing-list/
  - http://www.khronos.org/registry/webgl/specs/latest/
  - http://www.khronos.org/webgl/wiki/Testing/Conformance

OpenCL – Heterogeneous Computing

- **Framework for programming diverse parallel computing resources in a system**

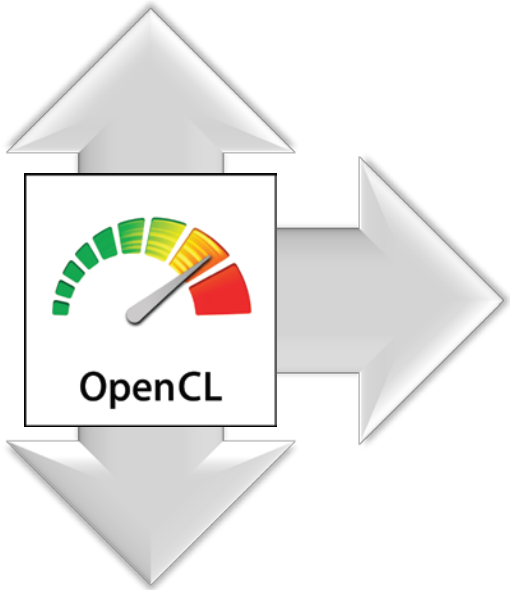
- **Platform Layer API**
  - Query, select and initialize compute devices
- **Kernel Language Specification**
  - Subset of ISO C99 with language extensions
- **Runtime API**
  - Execute compute kernels multiple devices
  - Gather results
- **OpenCL has Embedded profile**
  - No need for a separate “ES” spec



One code tree can be executed on CPUs or GPUs

OpenCL Roadmap

OpenCL-HLM **(High Level Model)**
Exploring high-level programming model, unifying host and device execution environments through language syntax for increased usability and broader optimization opportunities

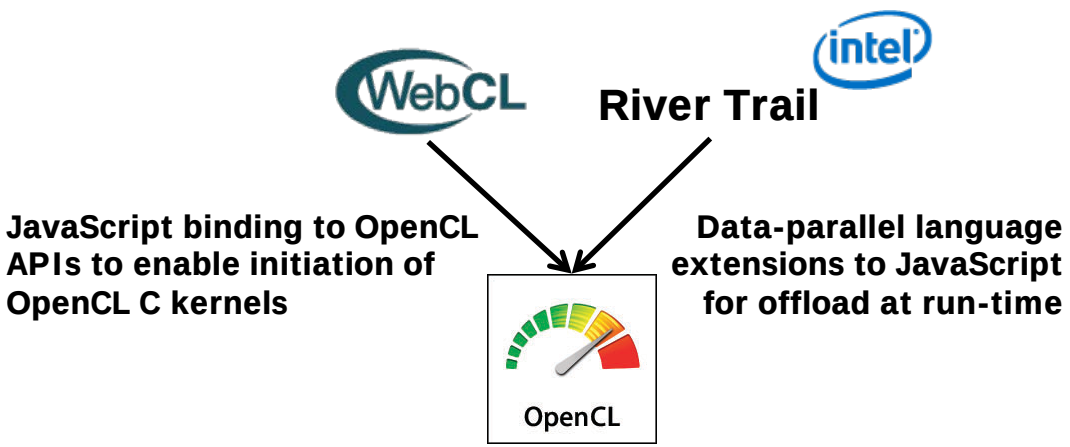


Long-term Core Roadmap
Exploring enhanced memory and execution model flexibility to catalyze and expose emerging hardware capabilities

OpenCL-SPIR **(Standard Parallel Intermediate Representation)**
Exploring LLVM-based, low-level Intermediate Representation for code obfuscation/security and to provide target back-end for alternative high-level languages

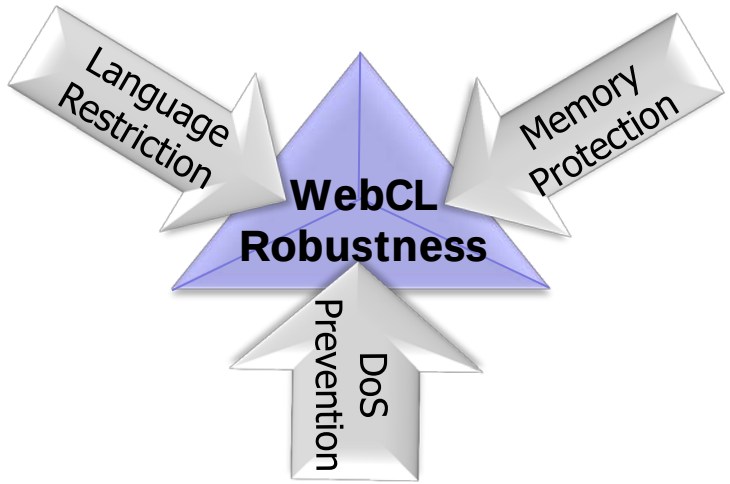
WebCL – Parallel Computing for the Web

- **JavaScript bindings to OpenCL APIs**
  - Enables initiation of Kernels written in OpenCL C within the browser
- **Bindings stay close to the OpenCL standard**
  - Maximum flexibility to provide a foundation for higher-level middleware
  - Minimal language modifications for 100% security and app portability
    - E.g. Mapping of CL memory objects into host memory space is not supported
- **API definition underway – public draft just released**
  - https://cvs.khronos.org/svn/repos/registry/trunk/public/webcl/spec/latest/index.html
- **Compelling use cases**
  - Physics engines for WebGL games
  - Image and video editing in browser



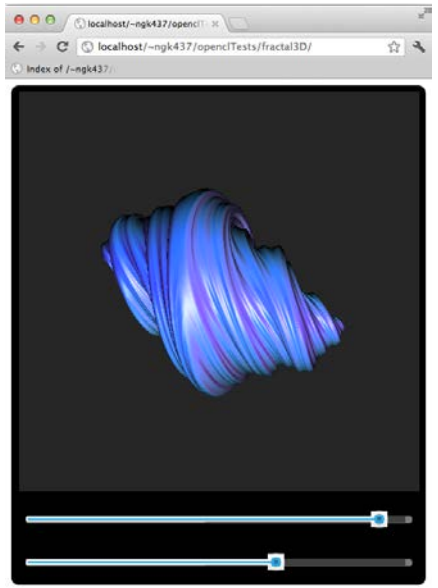
WebCL Security

- **Security is design imperative #1 for any Web standard**
  - Like WebGL – will be designed to be architecturally 100% secure
- **WebCL slipstreams much of the security robustness work of WebGL**
  - Plus additional protection for a more general purpose programming framework
- **WebCL language restrictions**
  - Disallowing pointers
- **Memory protection**
  - No out of bounds or uninitialized memory access
- **Detection and prevention of denial of service**
  - Extending WebGL robustness functions

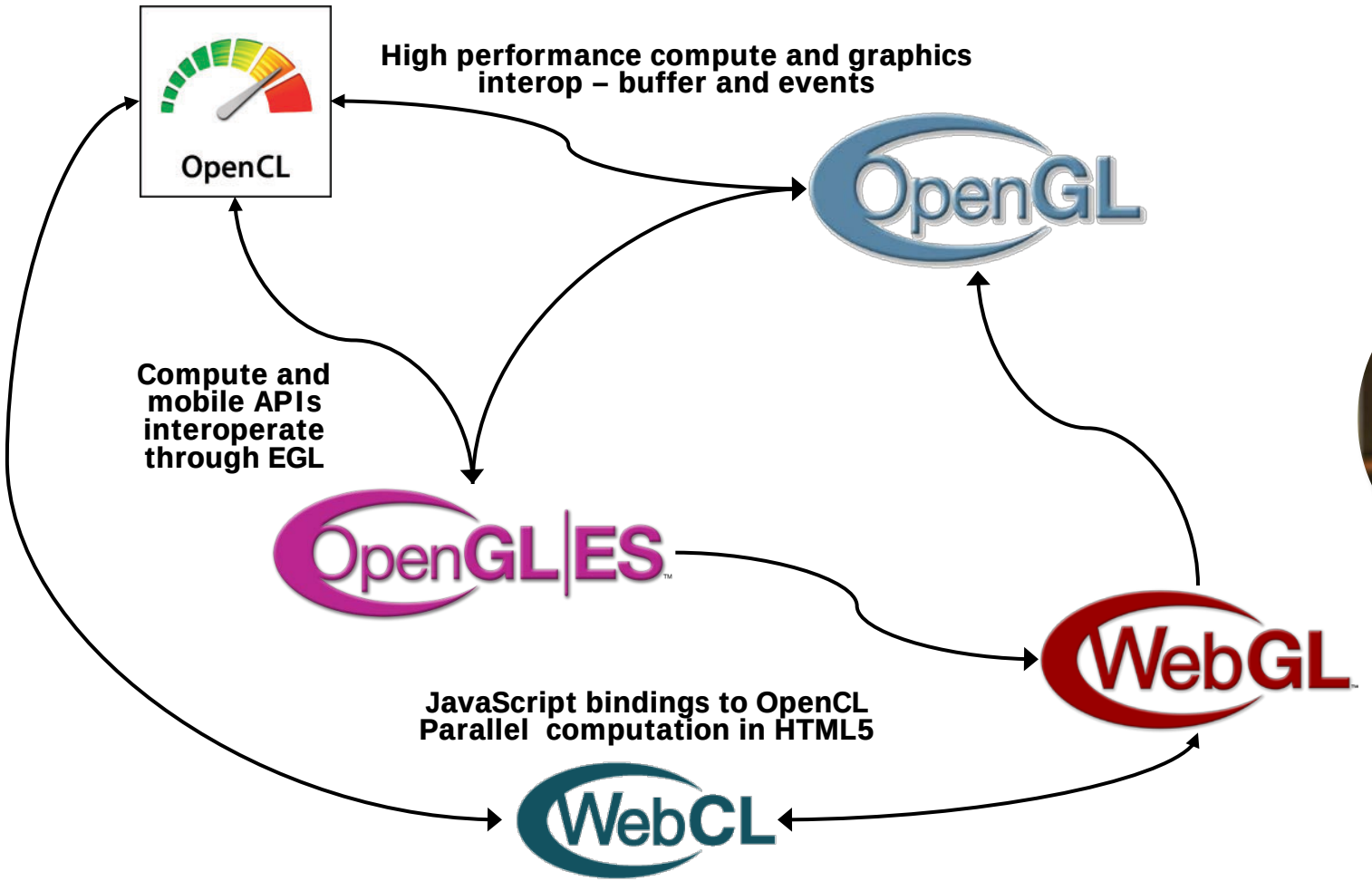


WebCL Open Process and Resources

- **Khronos open process to engage Web community**
  - Public specification drafts, mailing lists, forums
  - http://www.khronos.org/webcl/
  - webcl_public@khronos.org
- **Khronos welcomes new members to define and drive WebCL**
  - info@khronos.org
- **Nokia open sourced prototype for Firefox in May 2011 (LGPL)**
  - http://webcl.nokiaresearch.com
- **Samsung open sourced prototype for WebKit in July 2011 (BSD)**
  - http://code.google.com/p/webcl/
- **Motorola open sourced prototype for NodeJS and Chrome soon**



Visual Computing Ecosystem



COLLADA = XML Interchange of 3D Assets

- **COLLADA is a XML database schema for 3D assets**
  - Can hold *everything* to do with a scene: geometry with full skinning, advanced material and visual effects, animation, physical properties and collisions
- **COLLADA can be used to transport 3D assets between applications**
  - Enables binding of diverse DCC and 3D processing tools into a production pipeline
- **COLLADA is an open, archive-grade format that retains meta information**
  - Retains all information - even multiple versions of the same asset
- **COLLADA is NOT an transport format**
  - Conditioning pipelines optimize the asset database for a target device or usage

COLLADA Industry Momentum

Google

<AutomationML/>

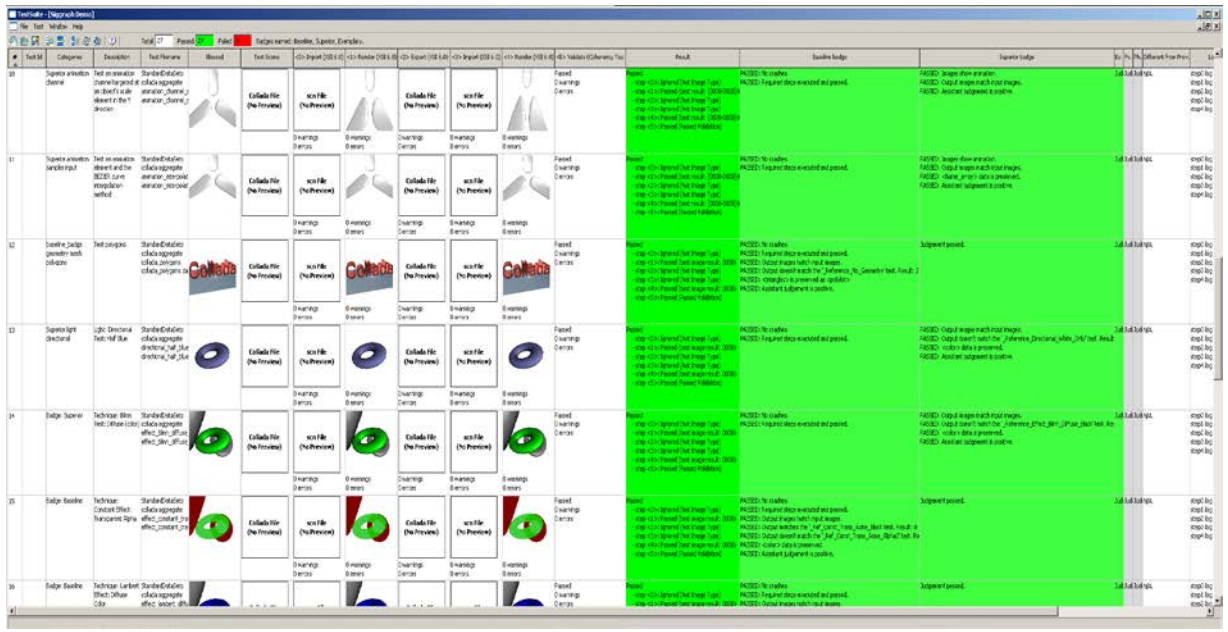
- **Apple**
  - Natively supports COLLADA in MacOS Lion and iBooks
  - Scene Kit framework in Mountain Lion.
- **Google**
  - Uses COLLADA in KML for Google Earth and SketchUp
- **Adobe**
  - Imports COLLADA directly in Creative Suite
- **AutomationML**
  - And the CAD industry are investing in COLLADA 1.5
- **ISO**
  - COLLADA is in process to become a ISO standard for the CAD industry
  - Key for long-term archival use cases

COLLADA™

KHRONOS GROUP

COLLADA Community Engagement

- **OpenCOLLADA Importer/Exporter and COLLADA Test Suite now on Github**
  - https://github.com/khronosGroup/OpenCOLLADA
  - https://github.com/KhronosGroup/COLLADA-CTS
- **Free to use**
  - To encourage widespread toolchain testing



COLLADA Test Framework

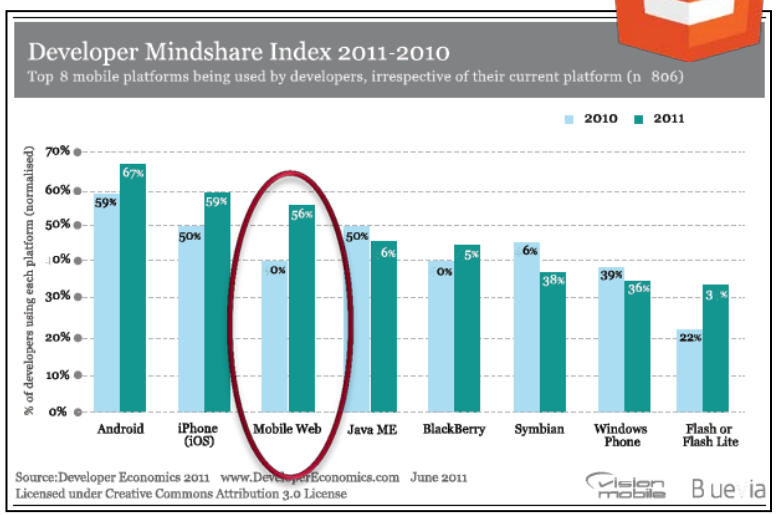
COLLADA and WebGL

- **COLLADA2JSON by Motorola Mobility**
  - COLLADA to JSON convertor
  - Bridging the gap between COLLADA and WebGL
  - JSON describes the scene graph - a separate binary blob all geometry
- **Open Source project being announced here at SIGGRAPH**
  - Uses OpenCOLLADA to convert COLLADA assets to JSON for use in WebGL
  - https://github.com/Motorola-Mobility/collada2json
- **JSON format driven by WebGL needs**
  - WebGL requires a unique final baked format
  - Indices buffer, split meshes > 65536 indices ...
  - Buffers description compliant with typed arrays
  - Creates WebGL shaders for COLLADA materials
- **Separate JSON scene graph description from assets**
  - Designed to be extended with compression for asset blob

KHRONOS GROUP

Web Apps versus Native Apps

- **Mobile Apps have functional and aesthetic appeal**
  - Beautiful, responsive, focused
- **HTML5 with accelerated APIs can provide the same level of "App Appeal"**
  - Highly interactive, rich visual design
- **Using HTML5 to create 'Web Apps' has many advantages**
  - Web app is searchable and discoverable through the web
  - Portable to any browser enabled system
  - Same code can run as app or as web page
  - Not a closed app store – no app store 'tax'
- **How soon will we be able to write *portable* AR in HTML5?**



Web Apps - Wider Ecosystem

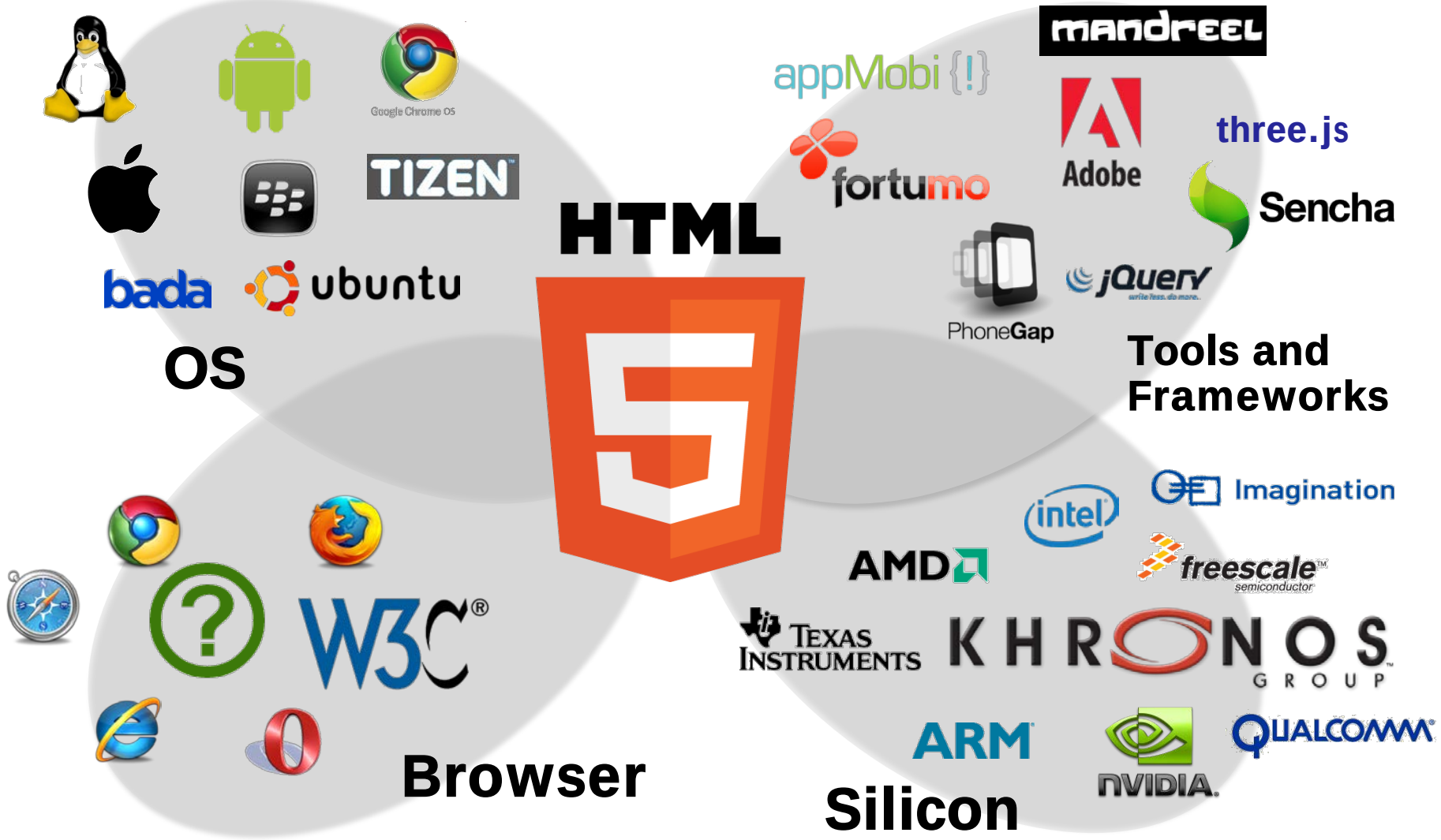
- **OS capability access before in HTML5**
  - Execution with no browser UI
  - Packaging standalone apps

- **OS Independent App stores**
  - Discovery and payment

- **Language and JavaScript Tools**
  - Native code compilation to JavaScript
  - JavaScript libraries

- **Authoring Tools**
  - Bringing Flash-grade authoring to HTML5

HTML5 Ecosystem Cooperation



Khronos at SIGGRAPH

- **Khronos BOFS at SIGGRAPH 2012 - Wednesday August 8th**
  - JW Marriott Los Angeles in the Gold Ballroom, Salon 3
  - http://www.khronos.org/news/events/siggraph-los-angeles-2012
- **News Conference at 1PM**
  - Headlines of all Khronos news announcements at SIGGRAPH
- **BOFS – 2-7PM**
  - COLADA, OpenCL, WebGL, OpenGL ES, OpenGL
- **OpenGL Party - 7-10PM**
  - **Beer**, basketball and prizes celebrating OpenGL's 20th Anniversary

In Summary

- HTML5 is at the center of a growing ecosystem of cross platform programming tools
- WebGL provides direct access to the GPU for web programmers
- WebCL will provide heterogeneous compute from JavaScript
- Significant cooperation underway between native and Web APIs to bring advanced visual computing to HTML5
- Khronos is driving open standards for hardware acceleration in HTML5
  Join, change the industry AND get the inside edge for your products!

KHRONOS GROUP