ALL ABOUT THE API

KHRONOS™ GROUP

The Landscape of Hardware APIs and Silicon Acceleration Opportunities

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Topics

How are *hardware acceleration APIs* unleashing new silicon capabilities for amazing user experiences?

How does the Khronos standards consortium create hardware acceleration APIs as *open standards*?

Why and how could you make your APIs into *collaborative* open standards?

Why Do We Need Standards and APIs?

- **Standards and APIs are *interoperability interfaces***
  - Streamlining product creation by reducing friction and fragmentation
- **A platform typically uses many interoperability standards e.g. mobile:**
  - E.g. LTE, WiFi, Bluetooth, HDMI, USB, MIPI CSI, JEDEC, GPS …
- **Also APIs for accessing services**
  - E.g. Google Maps, Facebook, Twitter …
- **And some APIs for accessing device hardware acceleration**
  - E.g. OpenGL ES, Vulkan, OpenVX …

E.g. standards drive mobile market growth by expanding mobile device capabilities

Open Standard APIs for Hardware Acceleration

PROMOTER MEMBERS

KHRONOS GROUP

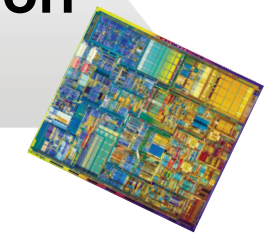
Over 130 members worldwide
Any company is welcome to join

AMD, Apple, ARM, Epic Games, Google, Huawei, Imagination, Intel, Nokia, NVIDIA, Qualcomm, Samsung, Sony, VeriSilicon

3D Incorporated, AdasWorks, Adobe, Altera, amazon.com, Axell Corporation, Axis Communications, BaseMark, Pinecone, Blizzard Entertainment, Broadcom, The Brenwill Workshop, cadence, Canonical, CEVA, codeplay, Columbia University, Continental, CoreAVI, Dassault Systèmes, OMP, EA, ETRI, Futuremark, Gaijin, Harman, Hitachi Inspire the Next, IBM, Imperial College London, ITRI, itseez, KDAB, Kishonti, KNU Kyungpook National University, LG, Linaro, Los Alamos National Laboratory, Marvell, matrox, maxplay, MAXON, MediaTek, Mentor Graphics, Microsoft, MIT Lincoln Laboratory, mobica, Movidius, mozilla, Multicore Ware, Nihon University, NEC, Nintendo, NXP, Oculus VR, ON Semiconductor, OSU Oregon State University, Panasonic, PIXAR, Politecnico di Milano, PRESAGIS, The Qt Company, Renesas, Rockwell Collins, Seoul National University, Silicon Studio, socionext, SPREADTRUM, symbio, Synopsys, TAKUMI, Tampere University of Technology, TU Wien Technische Universität Wien, Texas Instruments, Think Silicon, tobii, TOSHIBA, Unity, University of Bristol, University of Windsor, VALVE, VIA, Visteon, vmware, WARGAMING.NET, XILINX, zSpace

Software

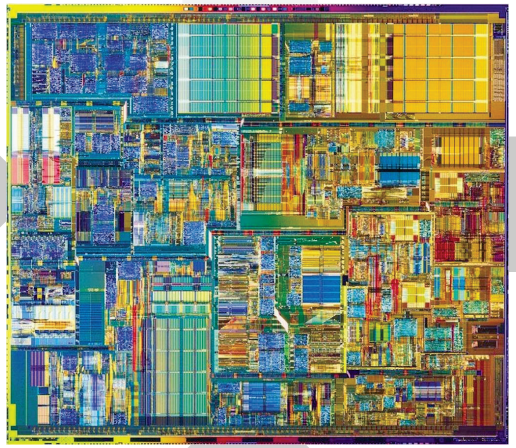
Silicon



Khronos is an Industry Consortium of over 100 companies creating royalty-free, open standard APIs to enable software to access hardware acceleration. Khronos APIs are used by *billions* every day.

http://accelerateyourworld.org/

Hardware APIs for Mobile and Web



3D for the Web
- JavaScript API for 3D Graphics
- Transmission of 3D runtime assets

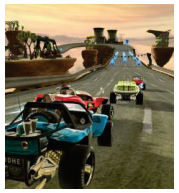
Vision / Camera
- Tracking and positioning
- Scene Analysis

3D Graphics
- Games and Virtual Reality
- Augmented Reality
- CG Effects
- Product Design

Parallel Computation
- Machine Learning
- Scene Comprehension
- 3D scene model construction
- Video Transcoding

Mobile 3D Graphics

Fixed function Pipeline



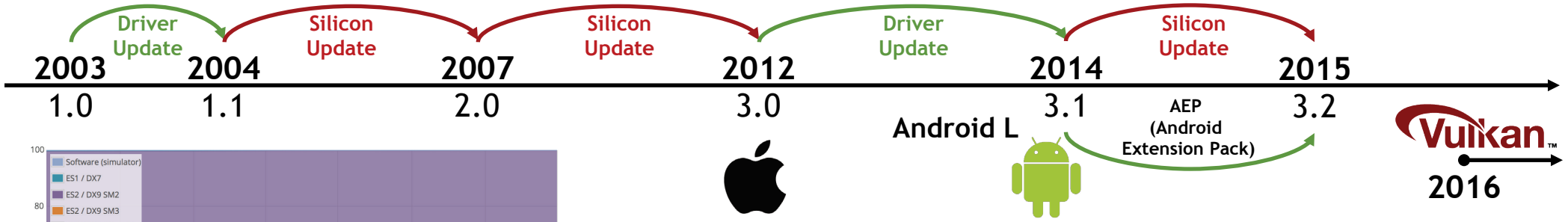
Programmable Vertex and fragment shaders

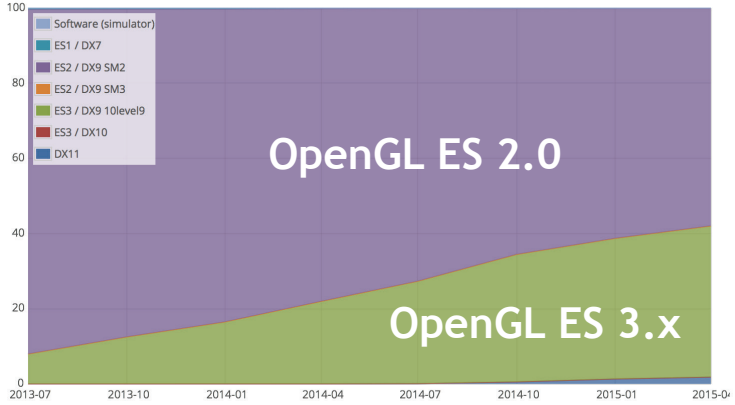
32-bit integers and floats
NPOT, 3D/depth textures
Texture arrays
Multiple Render Targets

Compute Shaders

Tessellation and geometry shaders
ASTC Texture Compression
Floating point render targets
Debug and robustness for security

Epic's Rivalry demo using full Unreal Engine 4
https://www.youtube.com/watch?v=jRr-G95GdaM





http://hwstats.unity3d.com/mobile/gpu.html

OpenGL ES

The most widely deployed 3D graphics API in history
Industry shipped close to 2 Billion OpenGL ES-enabled devices in 2015

3D Scene and Model Capture

- New integrated 3D sensors enable capture of scenes and objects
- Intense vision and compute processing needs acceleration

DOT PRODUCT

OpenVX™

OpenCL

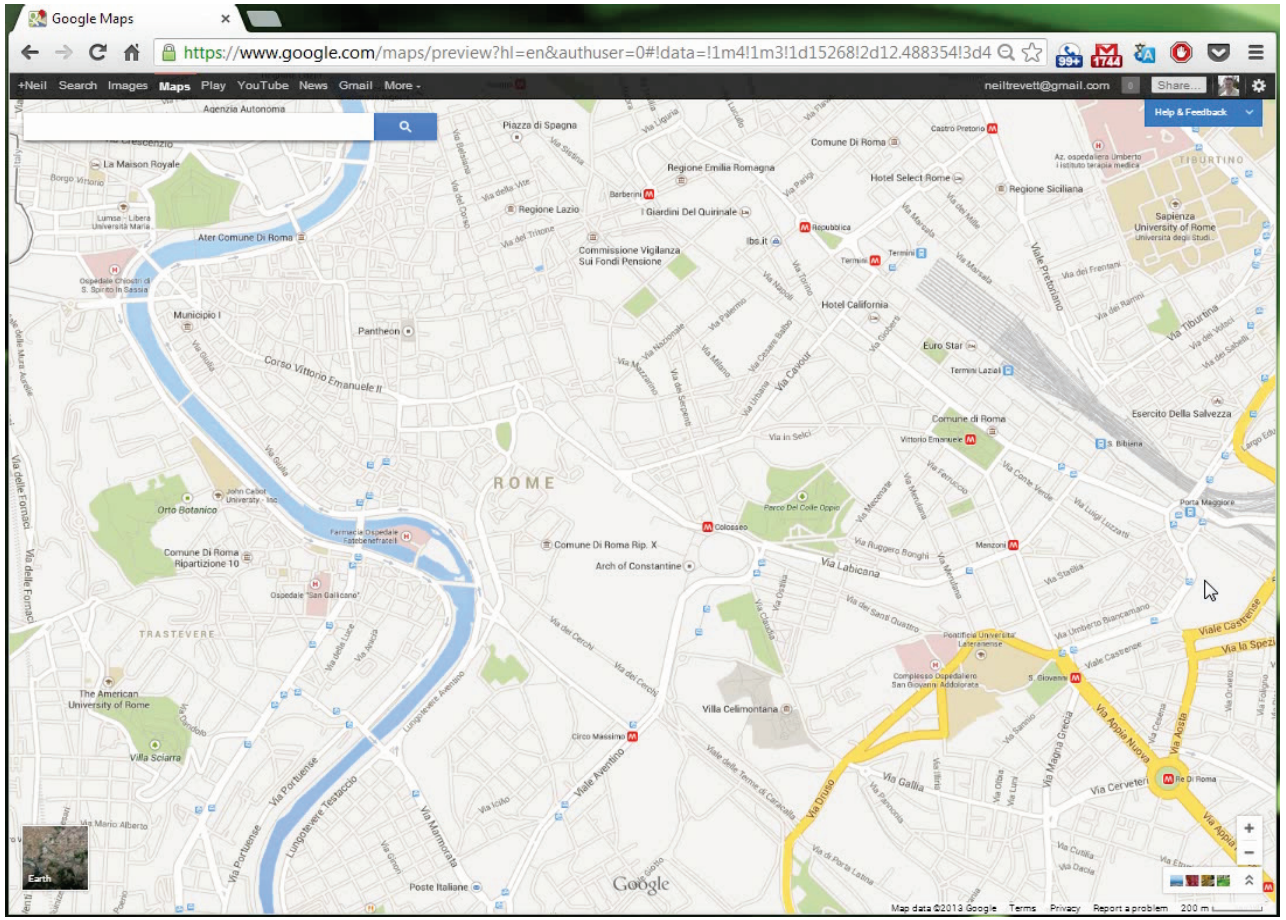
Augmented Reality - Bringing it all Together

- Vision processing to use depth sensor to understand the scene geometry
- Compute processing for mesh, lighting and physics processing
- 3D Graphics for displaying augmentations

Video courtesy of Occipital

Google Maps

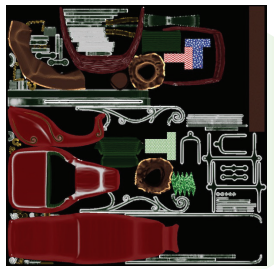
- All rendering (2D and 3D) in Google Maps uses WebGL



3D Needs a Transmission Format!

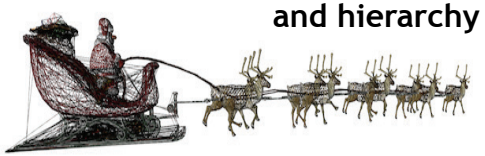
Audio	Video	Images	3D
MP3	H.264	JPEG	glTF
napster	YouTube	facebook	!

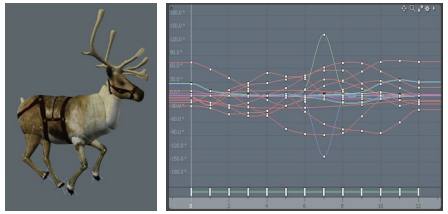
A widely adopted media format ignites previously untapped commercials opportunities



Materials and textures

Scene geometry and hierarchy

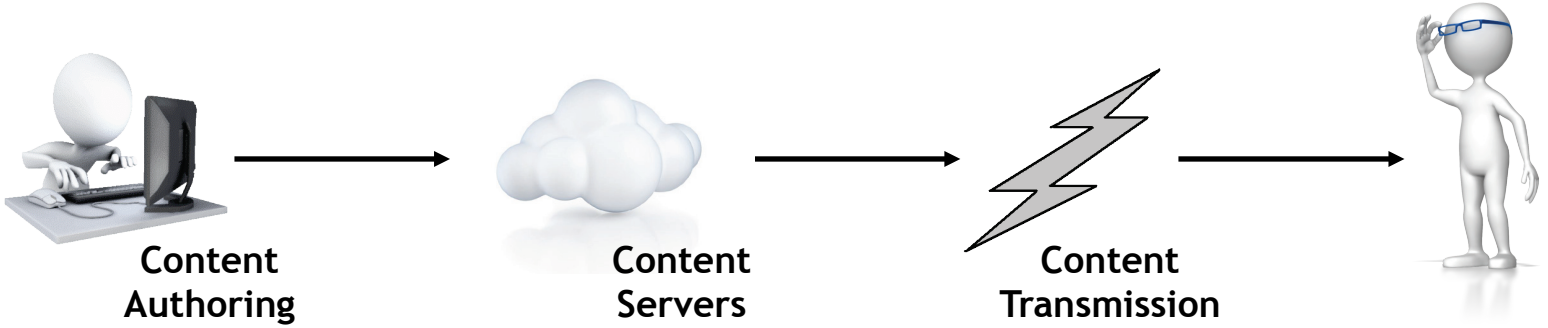




Animations and skins

glTF is used for NORAD's Santa Tracker Web Page

Khronos AR/VR Standards

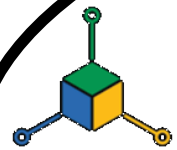


	Content Authoring	Content Servers	Content Transmission	Content Delivery
WITHOUT Standards	Tools import/export custom 3D formats and so do not interoperate	Every service/app stores 3D assets in a custom format -> Silo'd content	Long download times and proprietary code to unpack received 3D assets	Apps have to be ported to each device and often don't use acceleration
WITH Standards	Mix and match tool pipelines through common 3D asset import/export	3D assets are easily understood and used by any application and device	3D assets packed into efficient formats with streaming and compression	APIs provide consistent access to graphics, compute and vision acceleration
Khronos standards useful for AR	glTF, COLLADA	glTF, COLLADA	glTF	WebGL, Vulkan, OpenVX, OpenCL, OpenGL ES, OpenGL

AR/VR Will Need Many, Many Standards

3D is About to Go Social!

Object & scene capture



Search

Manufacturers provide 3D Object Descriptors - much more information than 2D search

Upload, View, Share and Comment

Social Loop

Photos -> JPEG -> Facebook
Videos -> H.264 -> YouTube
3D -> glTF -> ?

Print

3D Printing Service

Inspire and Motivate

Khronos Principles of Organization

Hardware APIs typically need to be open standards as a stable foundation for significant silicon product investments and for interoperability between multiple vendors

Any company is welcome to join
One company one vote

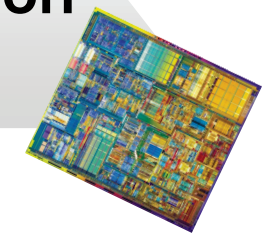
Any members can propose new standards initiatives

Software

Strong IP Framework to enable ROYALTY-FREE specifications: all members agree not assert patents against conformant implementations

Conformance Tests and Adopters Programs for defining conformance, specification integrity and cross-vendor portability

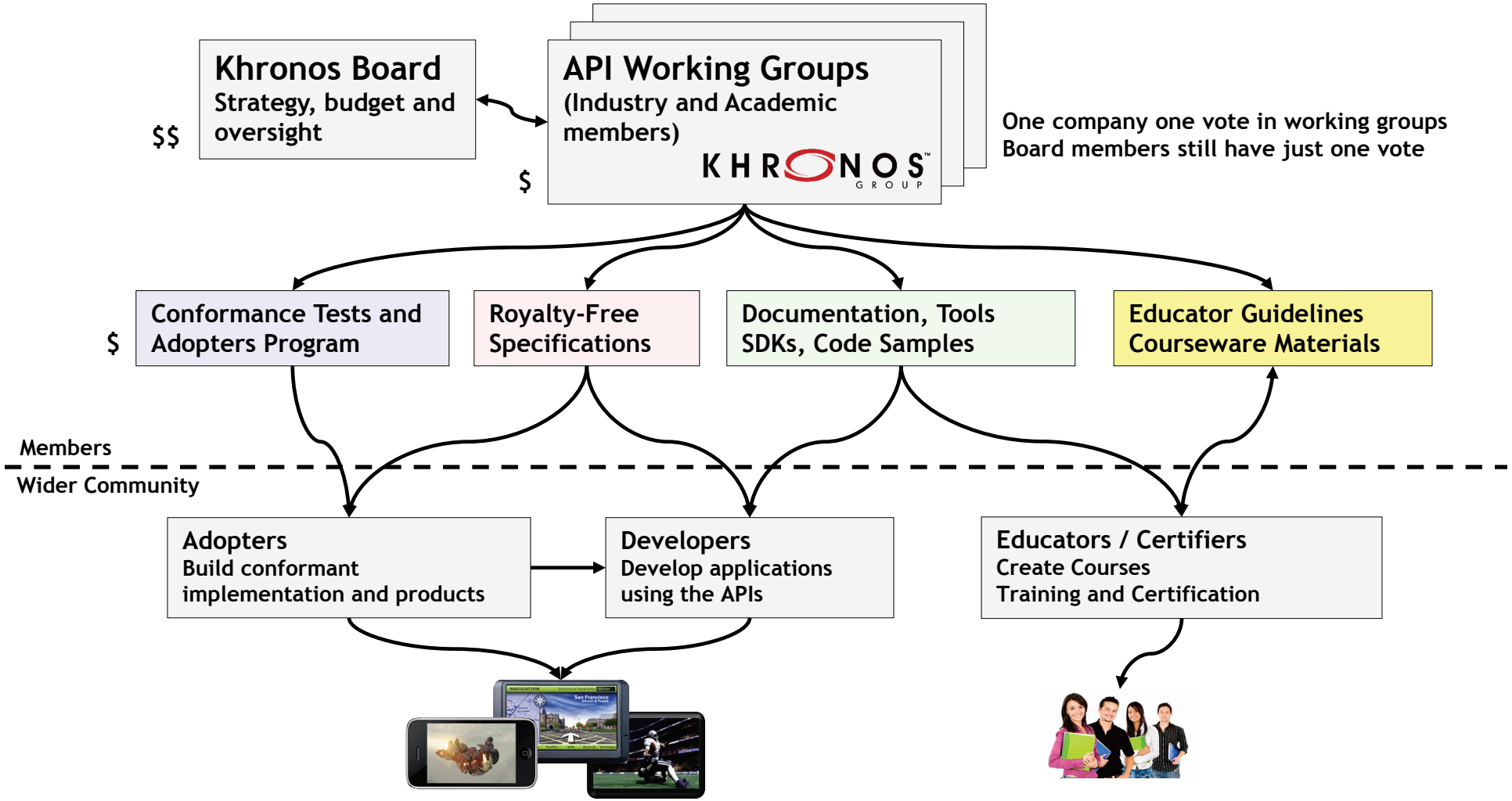
Silicon



Only invest where there is strong industry momentum to ensure industry relevance – let Darwinism rule!

Non-profit organization - Membership and Adopters fees cover operating, marketing and engineering expenses

Khronos Cooperative Framework



The Value of Khronos Participation

See an early window into the future of the industry technology roadmap before products are developed

Have a voice in how key standards evolve to suit *your* business needs

Develop products *in parallel* with spec drafting for faster time to market

Products are aligned with global market needs and trends

Members can ship products faster than non-members

Gather Industry Requirements for future silicon acceleration → Draft Specifications Confidential to Khronos members → Publicly Release Specifications and Conformance Tests → Non-members Release Products

The Khronos standardization process is proven to RAPIDLY generate industry consensus on future hardware acceleration functionality to EFFICIENTLY create new market opportunities

Khronos Conformance Process

Company implementing Khronos spec wishes to use the trademark E.g. “We have implemented OpenGL ES”

Company executes Adopters Agreement and pays fee (typically ~$20K for unlimited products) to enter Adopters program for an API

Port Test Source to products and generate test results

Upload test results to Khronos private web-site. Peer review by members/Adopters

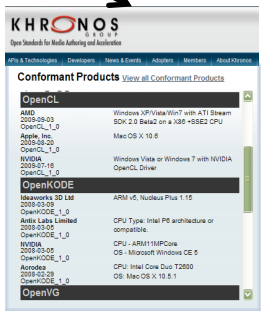
Successful Review enables products to use Khronos trademarks, be IP Protected and to be listed on Khronos website

Adopter Benefit

Restricted use trademark (not logo) with disclaimer language

Full use of logo and trademark with small disclaimer

Full use of logo and trademark AND IP Protection



When to Create an Open Standard?

REFINE well-formed API proposals NOT design by committee

Clear interoperability goals and requirements are agreed

Companies willing to share experience and technology

Lack of interoperability is clearly holding back market growth

Darwinian industry is still experimenting with what works and what doesn't

Consensus on best practices begin to emerge

Fighting for Open Standards

Multiple Companies Discover Collaborative Opportunity

Collaborating on a standard can grow more market opportunity than competing with proprietary technology

Effective Open Standard Strategies

1. Create joint investment in a standard-based solution that is too expensive for any one company to develop themselves
2. Create enough momentum that companies gain more than they lose by supporting an open standard

What Makes an API Standard Truly Open?

Open GOVERNANCE
Any company can participate in deciding the future of the standard
No-one company or group of companies dictates the fate of the standard over the wishes of others
E.g. one company one vote

Available for Any Company to Implement and Use
Specification available to any company
Feedback welcomed from the user community
E.g. Free-of-charge specs posted on the Web

Well-defined Intellectual Property Framework
Straightforward clarity on implementers rights and licenses to trademarks and IP
E.g. Royalty-free conformant implementations

What Makes a Successful Open API Standard?

Bad API Standard

- Overprescribes implementation details
- Forces everyone to implement a lowest common denominator
- Stifles innovation

-> Commoditization

Good API Standard

- Prescribes only interoperability
- Enables implementation diversity
- Encourages innovation

-> Differentiation

Open Standards and Open Source

- **Very different ways to cooperate**
  - Often confused with each other
- **Open standards do not always come with open source**
  - But they are often complementary

	Open Standards	Open Source
Governance	Defined working group decision process	Community driven
Primary Work Product	Normative specification	Shared open source repository
IP Framework	Precisely defined licensing obligations and protections in executed contract	Click through license in source headers
Conformance	Rigorous conformance test suite / process	Informal conformance tests, many forks
Typical Use Case	Production development & deployment	Rapid experimentation

Open source implementations and tools can be a powerful tool to promote and accelerate ecosystem adoption of open API standards

Get Involved!

- **Hardware needs APIs too!**
  - Many leading edge platform capabilities are being exposed through APIs
- **Khronos is committed to creating and promoting open standard APIs**
  - We would love to hear about the APIs you need for YOUR business
- **Any company or organization is welcome to join Khronos for a voice and a vote in any of its standards**
  - www.khronos.org
- **Neil Trevett**
  - ntrevett@nvidia.com
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