Creating the Platform for Embedded Media

**Neil Trevett
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President, Khronos Group
Chairman OpenGL ES Working Group**

Mobile Media is Growing Up Fast

- Handsets are rapidly gaining sophisticated media capabilities
- The largest volume potential for graphics hardware and software – ever!

State-of-the-art media API standards are needed to unleash the visual potential of battery-efficient graphics and media hardware on mobile platforms
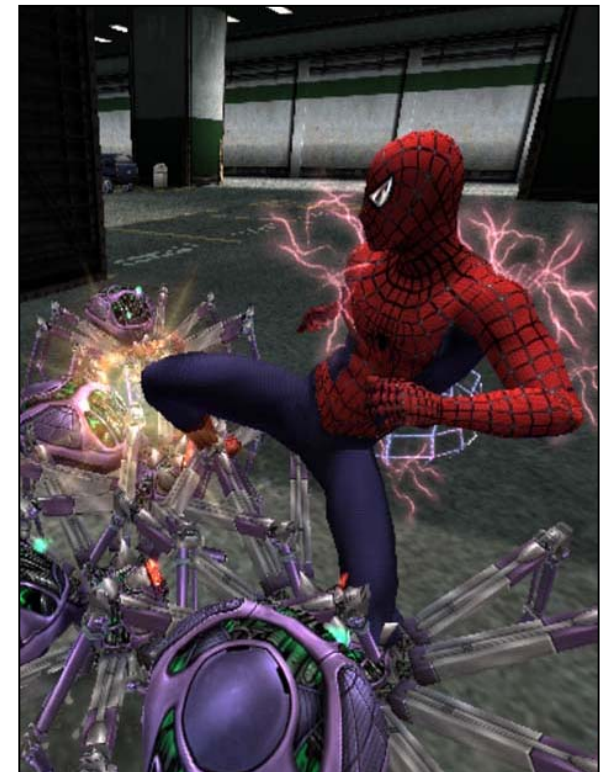
Spider-Man 2: The Hero Returns
Sony Pictures

2D

Spider-Man 2 3D: NY Subway
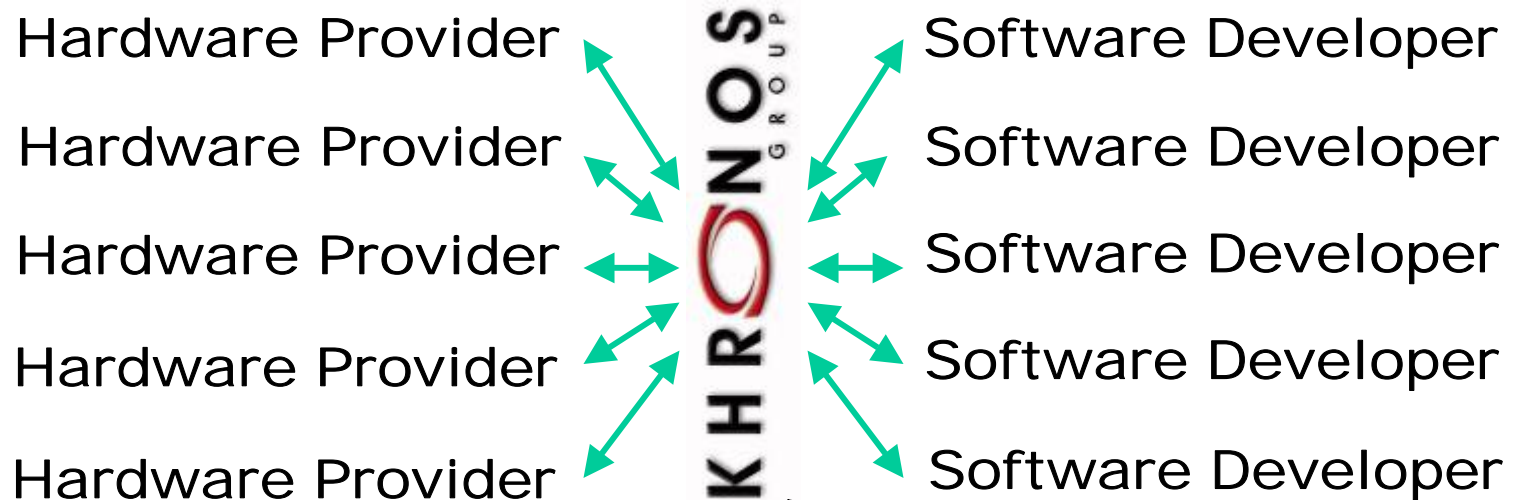Sony Pictures

3D Software

Spider-Man 2
Activision

3D with HW Acceleration
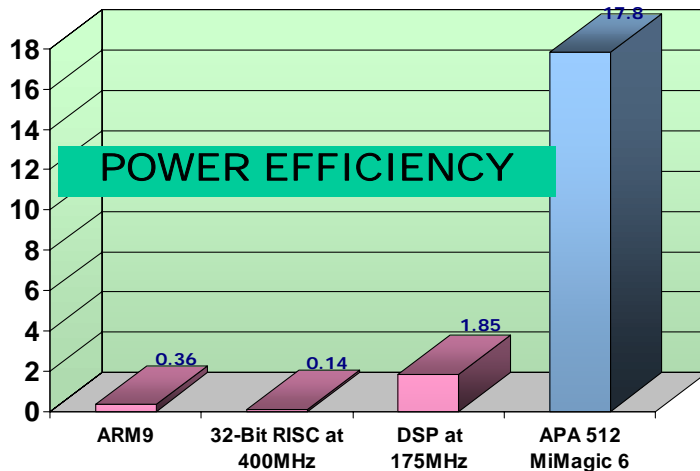
Media APIs Enable Market Growth

- An API is an agreement between hardware and software worlds
    - Enabling both - everyone wins

- ISVs see reduced variability across multiple platforms
    - More software can reach market faster at a better level of functionality and quality

- Hardware vendors can accelerate many applications
    - Adding value to their platform

Hardware Provider   KHRONOS GROUP   **Software Developer**

Hardware Provider   **Software Developer**

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Hardware Provider   **Software Developer**

Hardware Provider   **Software Developer**

An industry-standard media API enables any software to run on any conformant hardware

APIs Enable Mobile Acceleration

Faster Performance at Higher Quality
Hardware delivers at least 10 times the performance of software – even on low-cost systems with low-end CPUs

POWER EFFICIENCY

	17.8
ARM9	0.36
32-Bit RISC at 400MHz	0.14
DSP at 175MHz	1.85
APA 512 MiMagic 6	17.8

Less Power
Hardware accelerators exploit parallelism in a media pipeline to give a x10 increase in power efficiency over software

State of the art user interfaces
Smaller screens need more advanced graphics processing per pixel

Creating Open API Standards

Open Membership
Any company can join
Funded by membership dues

Open Standards
Royalty-free
Publicly available

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Open Standard APIs for Embedded Rich Media Acceleration

Cross Platform
Enabling diverse handheld and
embedded markets

Creates Industry Momentum
Specifications, Conformance tests,
Promotion and Education

**Khronos has a PROVEN reputation for
the TIMELY creation of HIGH-QUALITY,
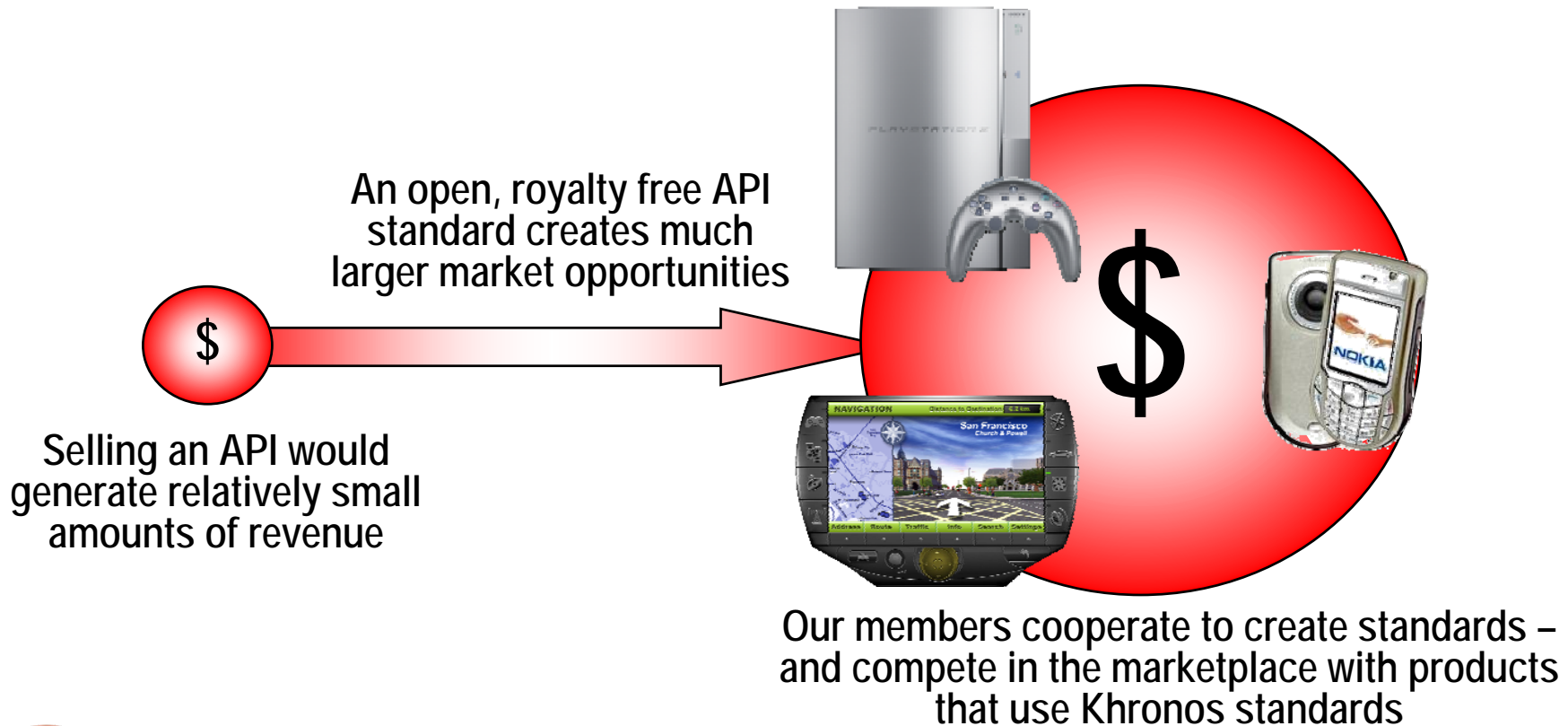ROYALTY-FREE standards**

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Over 90 companies creating media authoring and acceleration standards

How Does Khronos Make Money?

- It doesn't!

- Khronos is purely a non-profit organization
  - Funded by member dues – to cover costs

- Our members make money from selling PRODUCTS enabled by standards
  - NOT trying to charge for the standard itself

An open, royalty free API standard creates much larger market opportunities

$

Selling an API would generate relatively small amounts of revenue

$

Our members cooperate to create standards – and compete in the marketplace with products that use Khronos standards

Khronos Media Acceleration Platform

The Khronos API family provides a complete ROYALTY-FREE, cross-platform media processing platform

Applications or middleware libraries (JSR 184 engines, Flash players, media players etc.)

OpenGL|ES	EGL	OpenVG	OpenSL|ES	OpenMAX
2D/3D Graphics	Abstracted Access to OS Resources	2D Vector Graphics	Audio	Video, Audio and Image Media Framework

Media Silicon – CPUs, DSP, Hardware Accelerators etc.
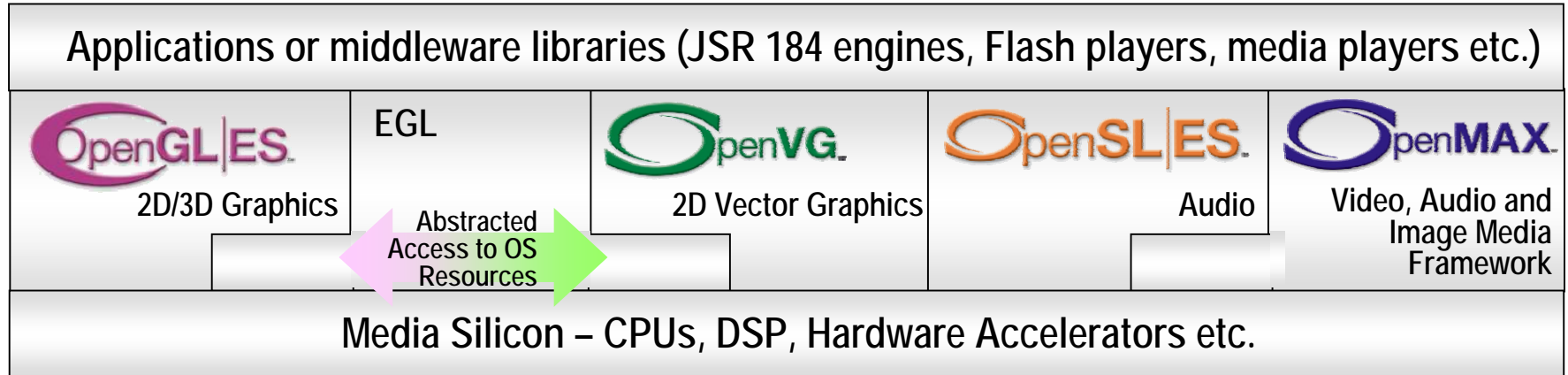
Khronos acceleration APIs use the lowest possible level of abstraction that provides application and silicon portability – without imposing policy

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OpenVG™

Accelerated Vector Graphics

Strong Demand for Vector Graphics

- Bezier curve based Vector Graphics are the foundation for high-quality 2D
  - Not polygon based – path based for scaling and positioning at full quality
  - Easy porting of content to different screen sizes

- Many applications use high-quality 2D vector graphics primitives
  - Portable mapping and GPS applications, E-book readers and text packages
  - Advanced user interfaces and screen savers, 2D Games

- Many vector graphics formats already in use
  - Flash, SVG, PDF, Postscript, Vector fonts etc. etc.

- But all 2D vector graphics runs un-accelerated!
  - Not effective on low-powered handset CPUs
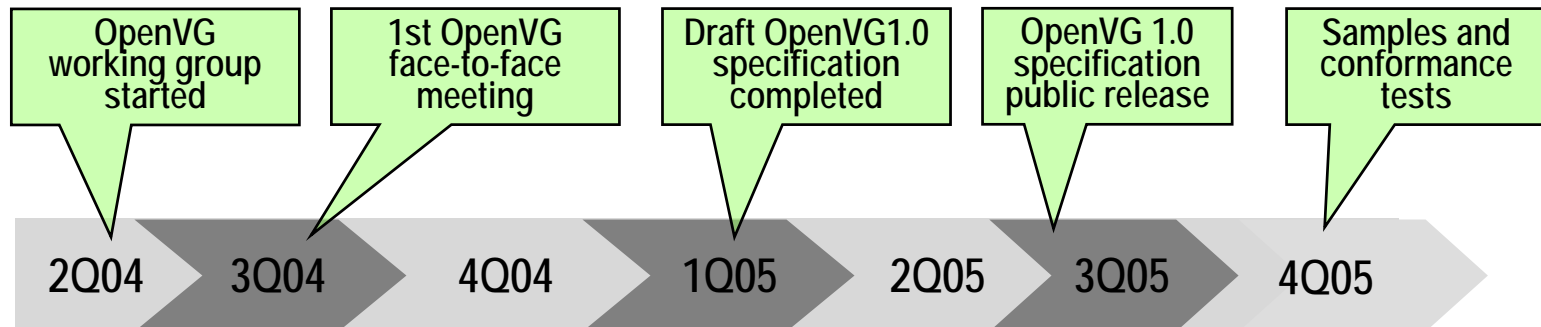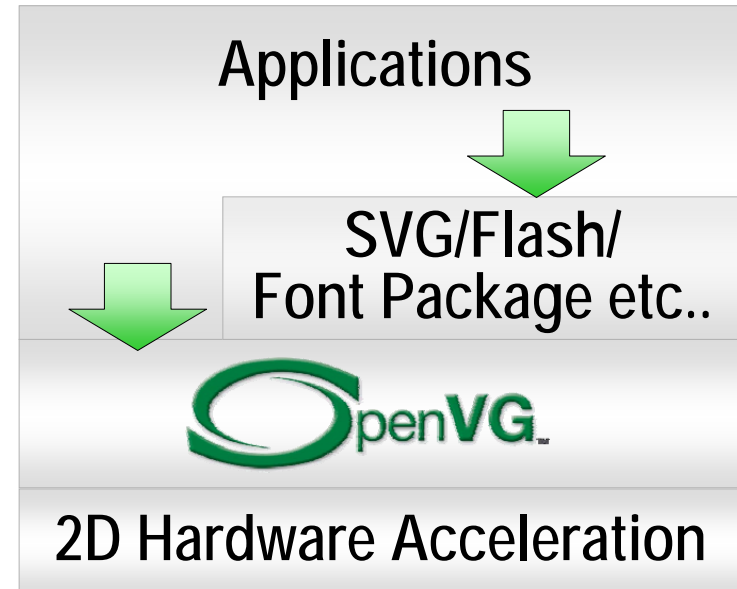
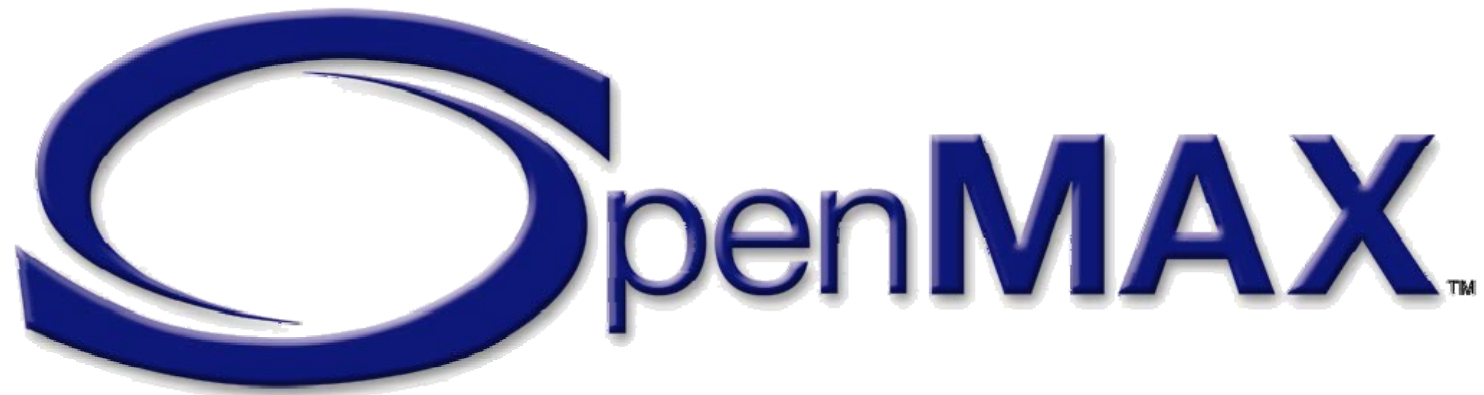curve   line   polygon   single-color   textured   linear gradient   radial gradient

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OpenVG.

OpenVG – Accelerated Vector Graphics!

- Low-level API for 2D vector graphics
  - With a focus on enabling hardware acceleration
  - Should also allow efficient SW implementations

- OpenVG ACCELERATES existing formats
  - NOT a competitor to Flash, SVG etc.

- Use OpenGL-style syntax where possible
  - Make learning OpenVG as easy as possible
    for OpenGL developers

- OpenVG 1.0 released at Siggraph 2005
  - Open, royalty-free standard

- Developed in just 12 months

Applications

SVG/Flash/ Font Package etc..

OpenVG

2D Hardware Acceleration

OpenVG working group started	1st OpenVG face-to-face meeting	Draft OpenVG1.0 specification completed	OpenVG 1.0 specification public release	Samples and conformance tests

2Q04 | 3Q04 | 4Q04 | 1Q05 | 2Q05 | 3Q05 | 4Q05

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OpenVG

Media Library Portability

Complete Media Library Portability

OpenMAX IL
Portability Across Operating Systems
Abstracted interfaces for media libraries into OS media frameworks

Wide range of video codecs, image and sound libraries etc.

OpenMAX DL
Portability Across Processors
Hotspot primitives to enable easy porting across hardware architectures

Application
Operating System Media Framework

OpenMAX IL – "Integration Level"
Media Primitives – provide portability to different operating systems

MP3	AMR	H.264	MPEG4	More Media Libraries

OpenMAX DL – "Development Level"
Media Primitives – provide portability of silicon acceleration

**Media Engines**
CPUs, DSP, Hardware Accelerators etc.

**OpenMAX public release around end of 2005**

Accelerated Embedded Audio

OpenSL ES Requirements

- Currently many closed proprietary audio APIs of varying functionality
  - Even playing a simple sound is achieved differently on different platforms

- OpenSL ES - unified, low-level audio acceleration API
  - Standard way to access any available audio hardware

- Cross-platform foundation for a wide range of higher-level audio APIs
  - Including JSR-234

- Application-oriented "developer" API
  - Standardize access to higher-level features: 3D positional audio, MIDI playback, DSP effects

- Similar abstraction-level to OpenGL ES and OpenVG
  - Complements "system" level audio component of OpenMAX

Applications

High-level Audio Libraries

OpenSL|ES

Audio Acceleration Hardware
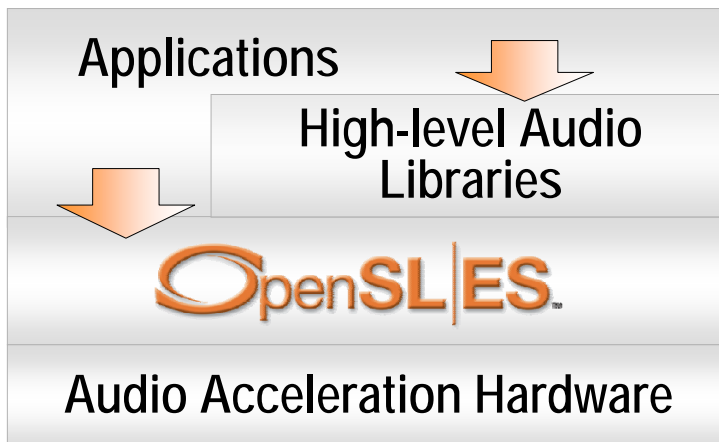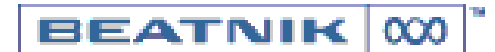
Industry Standard Embedded 3D

OpenGL ES API Standard

- Small-footprint subset of OpenGL
  - Created with the blessing and cooperation of the OpenGL ARB

- Powerful, low-level API with full functionality for 3D games
  - Available on all key platforms

- Royalty Free!!

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Feedback and Ratification

OpenGL ARB

Embedded Focus

Workstation Focus

Eliminate Redundancy

Strong functionality in a small footprint e.g. 50KB software engines

OpenGL|ES

OpenGL

Eliminate Workstation Functionality
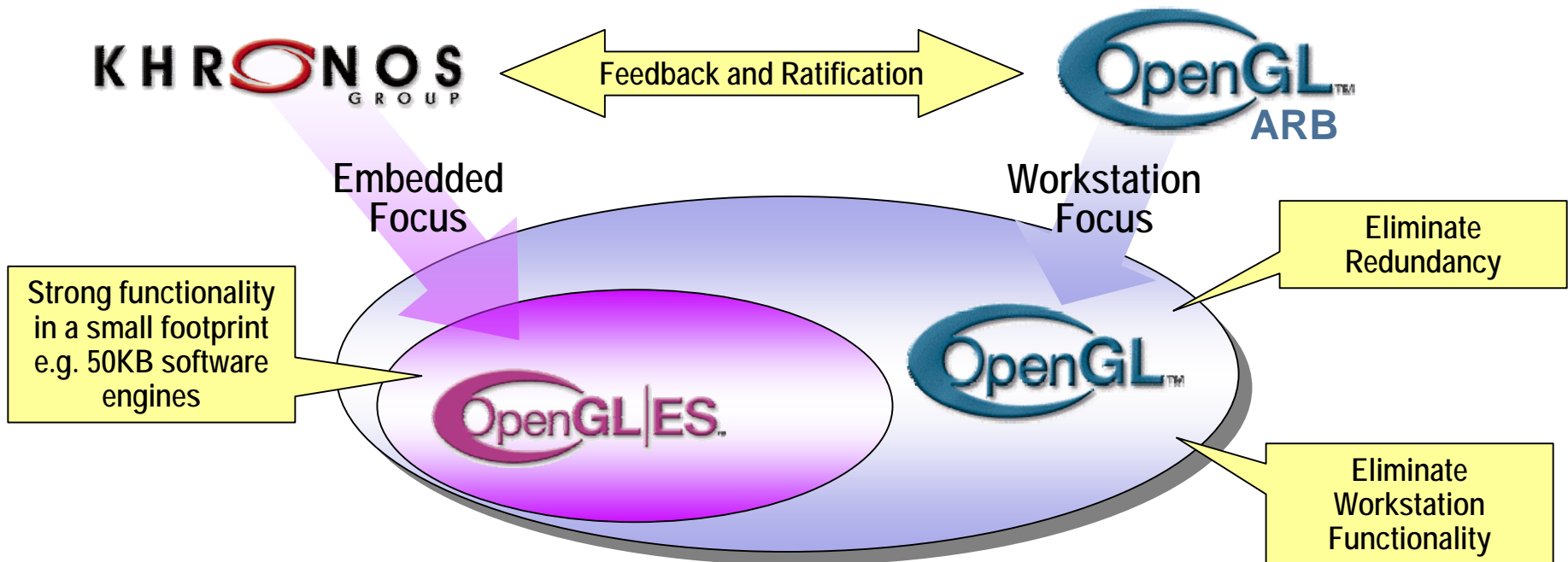
The OpenGL ES Family of Standards

OpenGL ES 1.X
OpenGL ES 1.0, 1.1 and 1.1 Extension Pack
- Evolving 3D functionality for software and fixed functionality hardware
- All 1.X specifications are backwards compatible

OpenGL ES 2.X
OpenGL ES 2.0
- 3D functionality for new-generation programmable hardware
- Incorporates GLSL ES shading language
- All 2.X specifications are backwards compatible
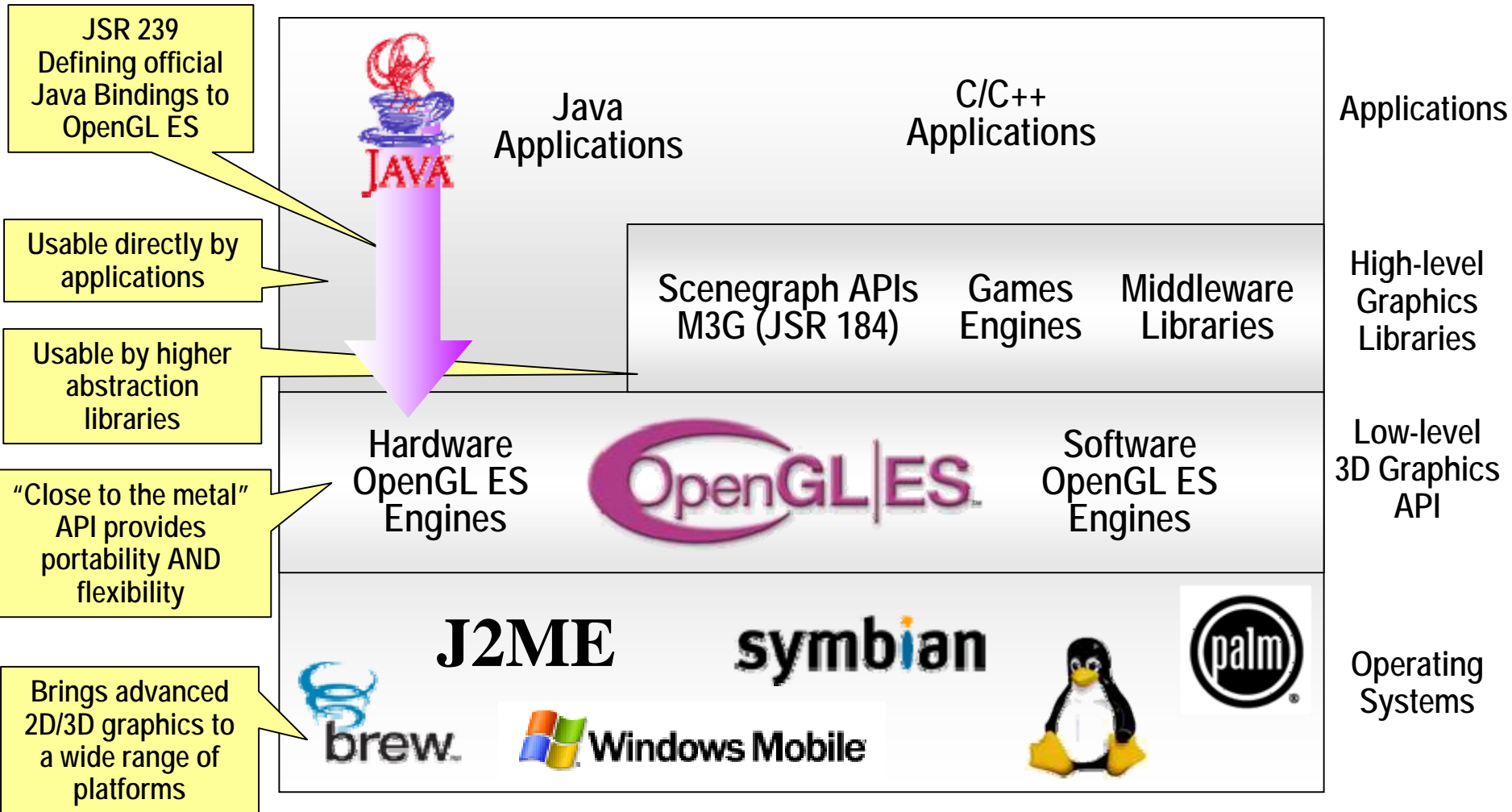
OpenGL ES-SC
OpenGL ES-SC 1.0
- 3D functionality for safety critical applications
- Military, avionics and automotive applications

EGL
EGL 1.0, 1.1 and 1.2
- Native platform window system interface
- Portable layer for graphics resource management
- Enables fast mixed-mode 2D/3D rendering using OpenGL ES and OpenVG

OpenGL ES – Central to Mobile 3D

JSR 239
Defining official
Java Bindings to
OpenGL ES

Usable directly by
applications

Usable by higher
abstraction
libraries

"Close to the metal"
API provides
portability AND
flexibility

Brings advanced
2D/3D graphics to
a wide range of
platforms

Java
Applications

C/C++
Applications

Applications

Scenegraph APIs
M3G (JSR 184)

Games
Engines

Middleware
Libraries

High-level
Graphics
Libraries

Hardware
OpenGL ES
Engines

OpenGL|ES

Software
OpenGL ES
Engines

Low-level
3D Graphics
API

J2ME

symbian

palm

Operating
Systems

brew

Windows Mobile

API Must Evolve at the Right Speed

Not too fast to prevent widespread adoption

Fast enough to encourage and expose new capabilities

OpenGL ES 1.1
Enhanced 3D running on
fixed-function hardware

OpenGL ES 1.0
3D running in
software on CPU

OpenGL ES 2.0
3D shaders running on
programmable hardware –

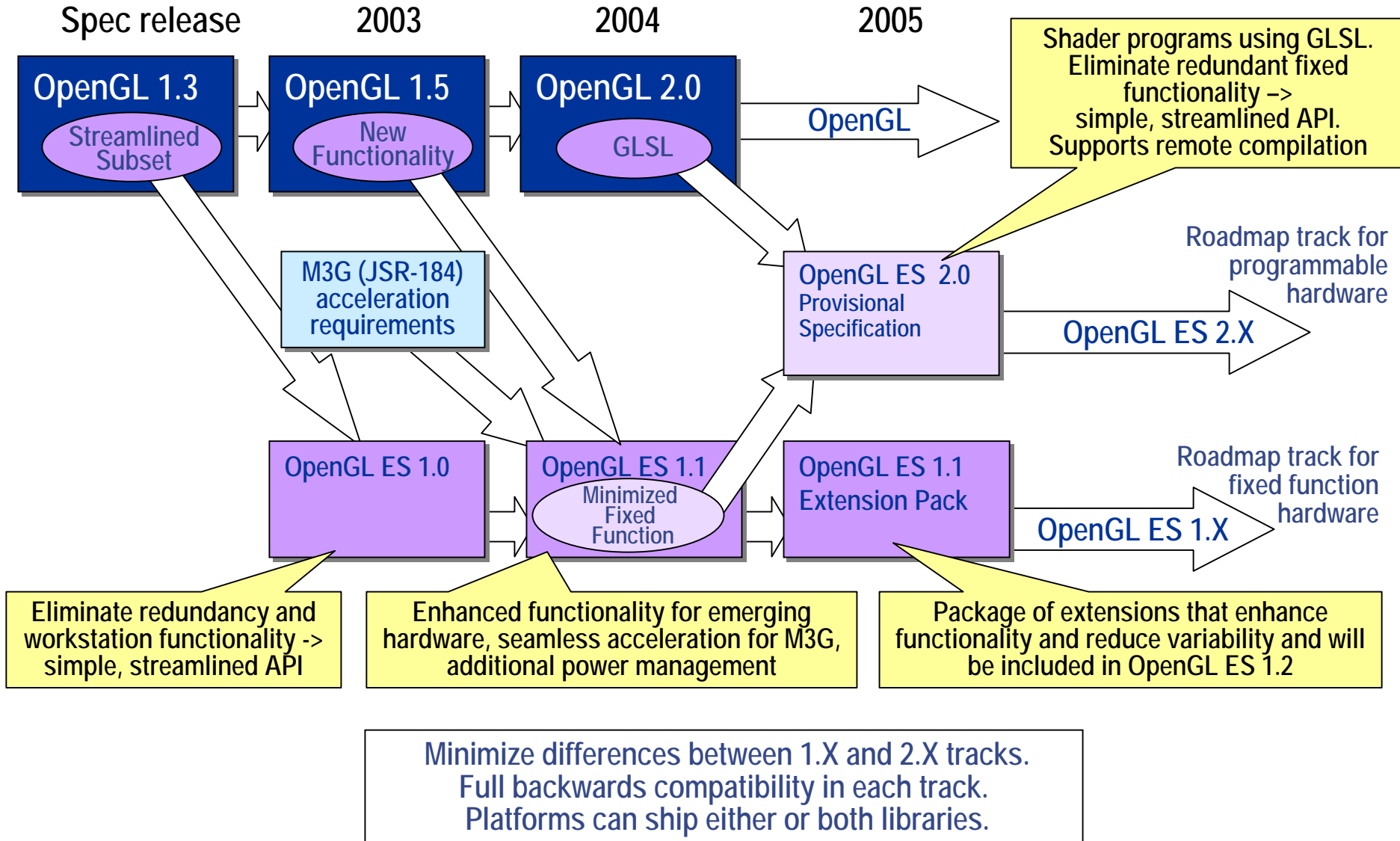New API versions currently
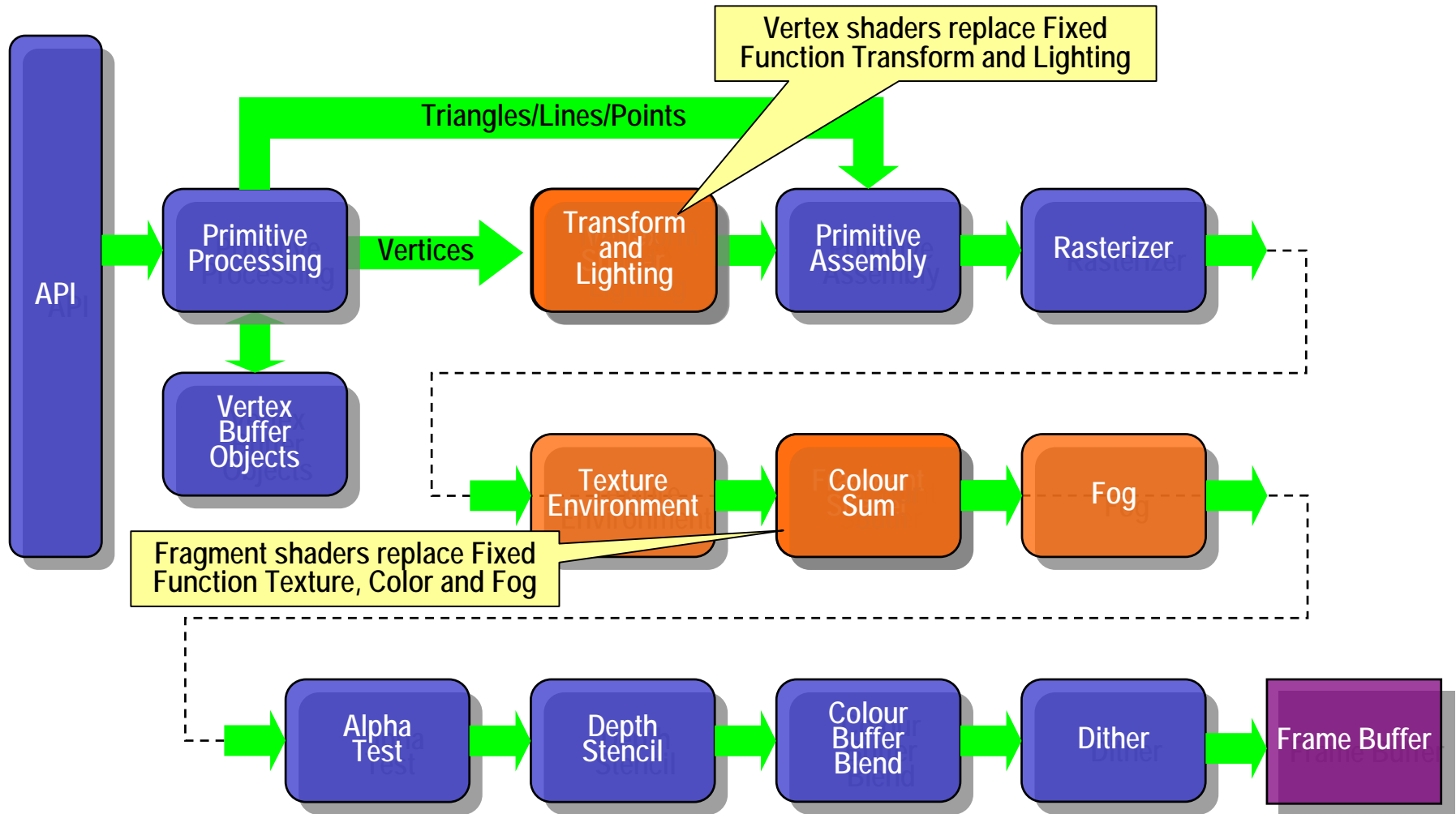needed every 12 months

Shipping
Products

2004   **2005**   **2006**

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OpenGL ES Roadmap – Two Tracks

Spec release   2003   2004   2005

OpenGL 1.3
Streamlined Subset

OpenGL 1.5
New Functionality

OpenGL 2.0
GLSL

OpenGL

Shader programs using GLSL. Eliminate redundant fixed functionality –> simple, streamlined API. Supports remote compilation

M3G (JSR-184) acceleration requirements

OpenGL ES 2.0
Provisional Specification

Roadmap track for programmable hardware

OpenGL ES 2.X

OpenGL ES 1.0

OpenGL ES 1.1
Minimized Fixed Function

OpenGL ES 1.1
Extension Pack

Roadmap track for fixed function hardware

OpenGL ES 1.X

Eliminate redundancy and workstation functionality -> simple, streamlined API

Enhanced functionality for emerging hardware, seamless acceleration for M3G, additional power management

Package of extensions that enhance functionality and reduce variability and will be included in OpenGL ES 1.2

Minimize differences between 1.X and 2.X tracks.
Full backwards compatibility in each track.
Platforms can ship either or both libraries.

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OpenGL|ES

OpenGL ES 2.0 Programmable Pipeline

Vertex shaders replace Fixed Function Transform and Lighting

Fragment shaders replace Fixed Function Texture, Color and Fog

Triangles/Lines/Points

API

Primitive Processing → Vertices → Transform and Lighting → Primitive Assembly → Rasterizer

Vertex Buffer Objects

Texture Environment → Colour Sum → Fog

Alpha Test → Depth Stencil → Colour Buffer Blend → Dither → Frame Buffer

Shaders - Next Generation Mobile 3D

3D Today
Fixed Functionality

3D Tomorrow
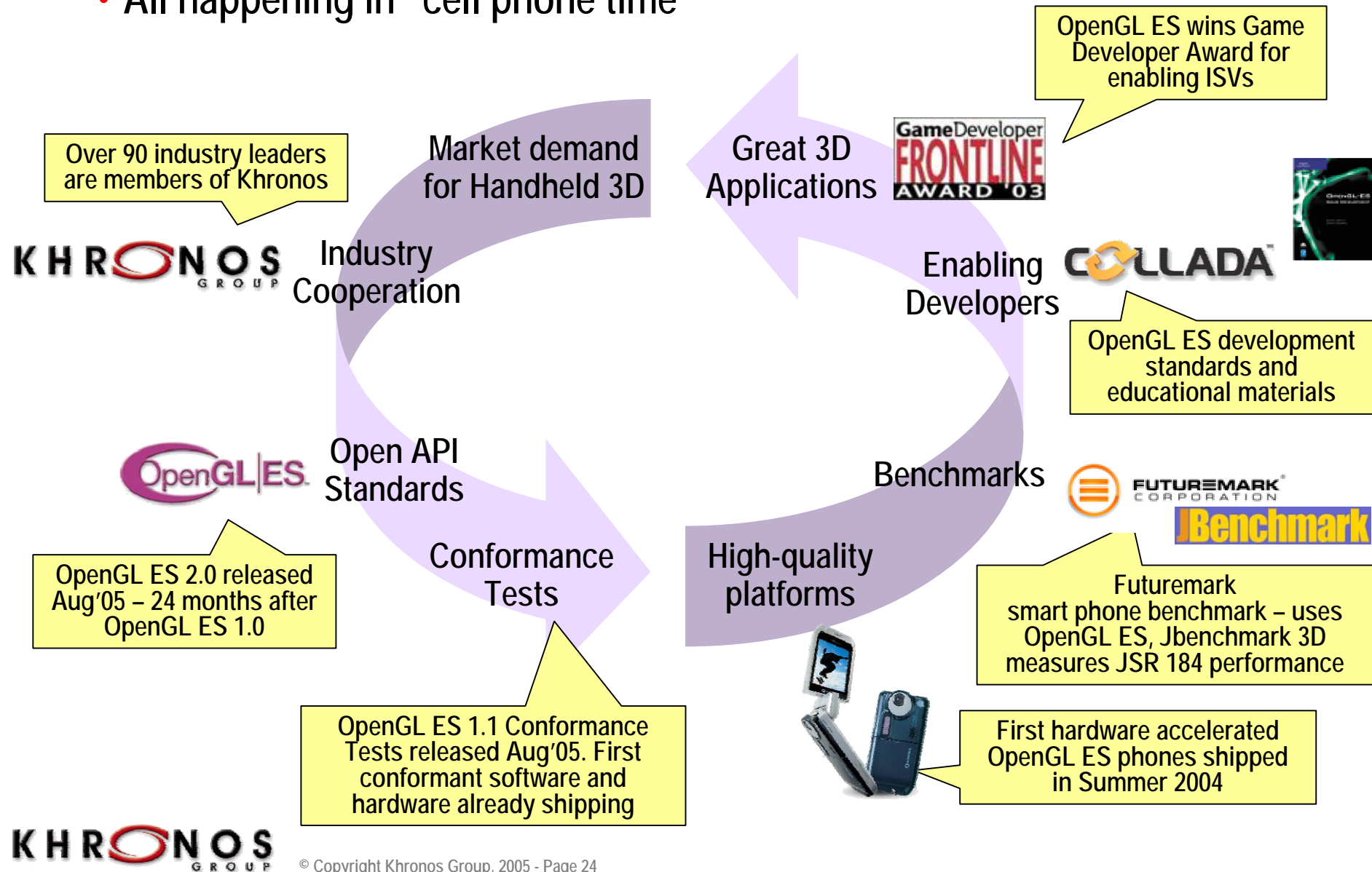- Shader Programmability

Doom 3's Zombies

Unreal's Rocks

Halo's Ice

Far Cry's Water

Building the Graphics API Ecosystem

- All happening in "cell phone time"

OpenGL ES wins Game Developer Award for enabling ISVs

Over 90 industry leaders are members of Khronos

Market demand for Handheld 3D

Great 3D Applications

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Industry Cooperation

Enabling Developers

OpenGL ES development standards and educational materials

OpenGL|ES

Open API Standards

Benchmarks

OpenGL ES 2.0 released Aug'05 – 24 months after OpenGL ES 1.0

Conformance Tests

High-quality platforms

Futuremark smart phone benchmark – uses OpenGL ES, Jbenchmark 3D measures JSR 184 performance

OpenGL ES 1.1 Conformance Tests released Aug'05. First conformant software and hardware already shipping

First hardware accelerated OpenGL ES phones shipped in Summer 2004

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COLLADA™

Tools! Tools! Tools!

We have to make 3D titles as EASY as possible to develop

OpenML™

COLLADA™

MEDIA AUTHORING

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Synergistic Development of Authoring and Acceleration Standards

Tools and standards to create and distribute compelling embedded content

Authoring requirements for embedded devices and platforms

OpenVG™ OpenMAX™

OpenGL|ES™

OpenSL|ES™

MEDIA ACCELERATION

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Collada - Tools and Playback Synergy

- Digital Asset Exchange Schema – making ISVs more productive
  - Enables 3D authoring tools to work together to raise the power of tool chains

- Packaging format for content delivery – including shaders and physics
  - COLLADA FX and COLLADA Physics

- Strong synergy between COLLADA and OpenGL ES 2.0
  - Collada enables shaders to authored and packaged using OpenGL ES Shading Language

Collada enables leading 3D authoring tools to work effectively together to create OpenGL ES applications and assets

Assets – including shaders and physics can be communicated between tools and packaged for OpenGL ES delivery

Ubiquitous acceleration API for 3D content and shaders using OpenGL ES 2.0

3ds max

SOFTIMAGE|XSI

COLLADA

OpenGL|ES

Collada 1.4 will be ratified in October 2005 and will Include shader and physics metafile data definitions

Tightly Integrated 3D Authoring and Deployment Stack

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Conditioning Pipeline

Collada is a vital bridge between modelers and run-time engines

Collada enables assets and shaders to be conditioned for real-time delivery - including adapting content specifically to the capability of different platforms without losing key asset data

Authoring Applications   **C☺LLADA™**

User Applications

OpenMAX Media Frameworks
E.g. OpenMAX IL, Symbian MDF, GStreamer, DirectShow, MMAPI

Graphics APIs

OpenGL|ES 3D Acceleration in small footprint

Media Libraries
Video Codecs, Imaging and Sound libraries etc. etc.

OpenVG 2D Vector Graphics Acceleration

OpenMAX OpenMAX DL codec and media library portability

Media Engines – CPUs, DSP, Hardware Accelerators etc.

Automatic conditioning can help hide platform variability from developers

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OpenGL ES and Sony PlayStation 3

- OpenGL ES will be available for Playstation 3
  - Sony made public announcement at GDC in San Francisco in March 2005
  - All interactive demos at E3 were using OpenGL ES

- Many ISVs code for PlayStation first and then port to other platforms
  - Tools are essential to hide platform variability

- Powerful portability for console and handset titles
  - Previous generation console games can be deployed on 100s of millions of cell phones

Application portability across a wide range of platforms
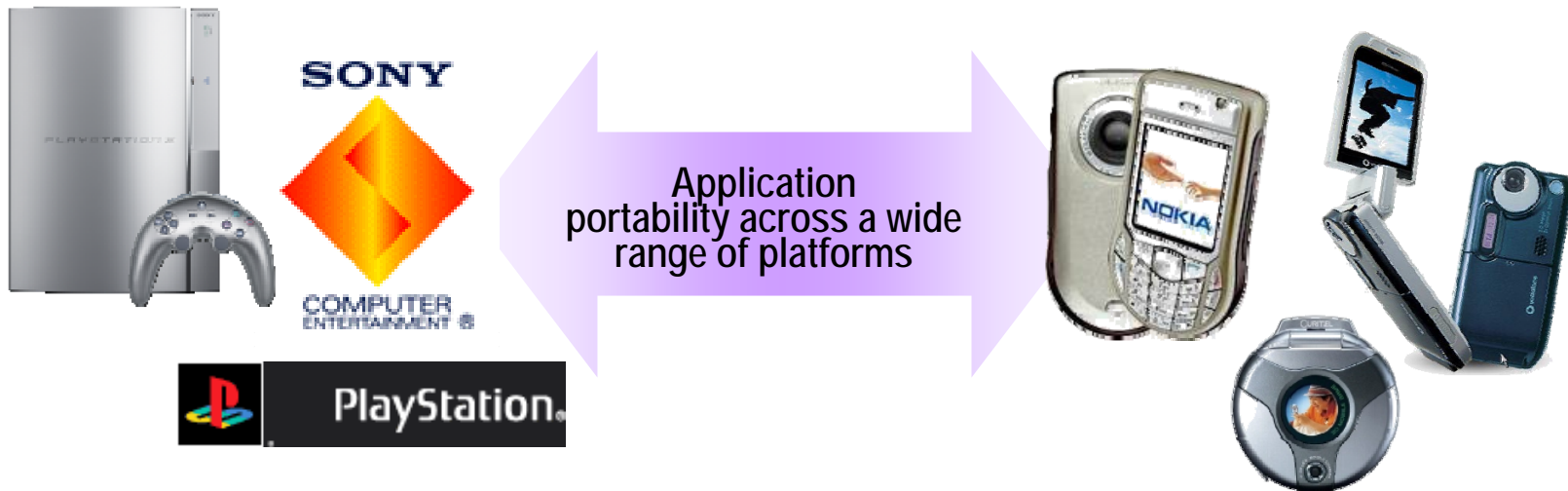
THE POWER OF COOPERATIVE OPEN STANDARDS
A growing infrastructure of OpenGL ES tools and platforms are creating the world's largest opportunity for games developers

SKT and KTF Launch Games Sites

- Includes 3D OpenGL ES-based games
- www.gxg.com and www.gpang.com games portals – launched in 2005

3D Deployment Evolution

Latest JBenchmark Results

Increasingly large percentage of JSR 184 engines use OpenGL ES for hardware acceleration

Java – Hardware Accelerated JSR 184 Engines

OpenGL|ES

2005

Initial shipping titles used software JSR 184 - based engines
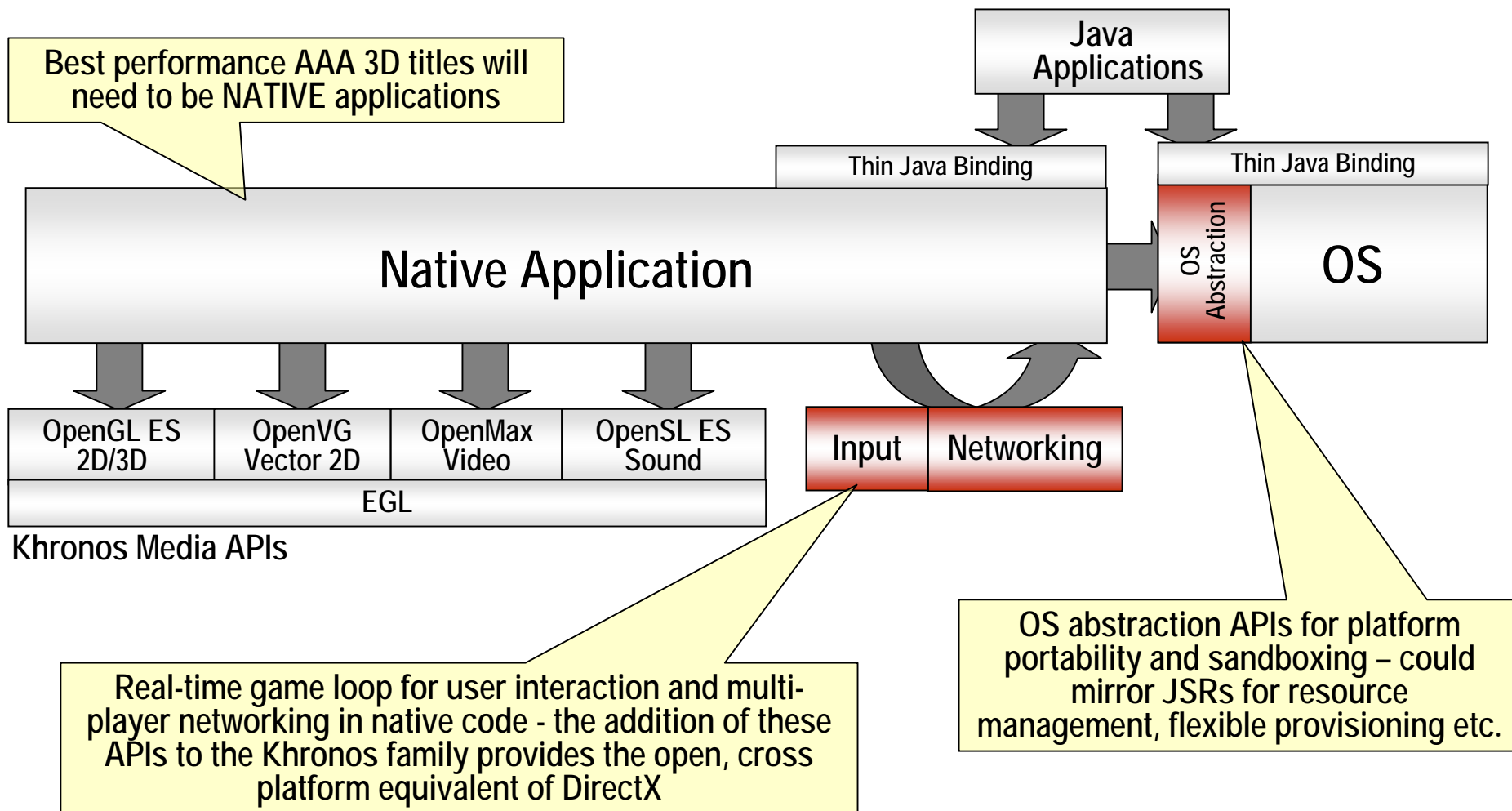
Java - JSR 184 Software Engines

2004

Strong industry momentum building for JSR 184 titles on Java platforms

OpenGL ES Native Applications

OpenGL|ES

2006

Opportunity for platforms with native application support to ship native OpenGL ES applications for significantly higher 3D performance

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Should Khronos Do More?

Best performance AAA 3D titles will need to be NATIVE applications

Java Applications

Thin Java Binding

Thin Java Binding

Native Application

OS Abstraction

OS

OpenGL ES 2D/3D

OpenVG Vector 2D

OpenMax Video

OpenSL ES Sound

EGL

Khronos Media APIs

Input | Networking

Real-time game loop for user interaction and multi-player networking in native code - the addition of these APIs to the Khronos family provides the open, cross platform equivalent of DirectX

OS abstraction APIs for platform portability and sandboxing – could mirror JSRs for resource management, flexible provisioning etc.

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Why Use Khronos Standards?

- A complete and coherent media acceleration platform
  - A family of media APIs designed to work together

- "Foundation Level" APIs
  - Close to the silicon – fundamental functionality needed on every platform

- Designed by industry experts
  - The industry leaders in media silicon, platform and software are all Khronos members

- Reduces development and deployment costs
  - Widespread industry adoption ensures competitive silicon and software supply chain

- Flexible, fast-track roadmap evolution
  - Effective and streamlined process – specification updates every 12 months if needed

- All Khronos APIs are extensible
  - Enables rapid and unconstrained platform differentiation

- Royalty-free
  - Khronos Committed to generating market opportunities for its members and the industry

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Any Questions?

Slideset available for download at www.khronos.org