Creating the Foundation for Embedded Media Processing

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Agenda

• The need for embedded media API standards
• The mission and structure of the Khronos Group
• Overview of the Khronos APIs
• OpenGL ES – embedded 3D graphics
• OpenVG – 2D vector graphics acceleration
• OpenMAX – making media codecs and libraries portable
• Questions

• These slides are available at www.khronos.org
Rich Media Market Opportunity

- Handhelds becoming capable of playing rich media
  - New rich media features increase number of applications and users
- Khronos API standards enable media acceleration
  - Without standards market growth is slowed
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

An industry-standard media API enables any software to run on any conformant hardware
Small Screens Need Advanced Media

- Smaller screens need more advanced graphics processing per pixel
  - To make best use of restricted screen real-estate
- Advanced graphics techniques provided by state-of-the-art media APIs
  - 2D and 3D, anti-aliasing, multi-level compositing, video processing

Interactive 3D Gaming Content

Video Processing & synchronization

Perspective windows maximize screen real-estate

Translucent Menus don’t obscure lower layers

Anti-aliased vector graphics makes small text extremely legible
Creating Open API Standards

Open Membership
Any company can join
Funded by membership dues

Open Standards
Royalty-free
Publicly available

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
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

Selling an API would generate relatively small amounts of revenue

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

Our members cooperate to create standards – and compete in the marketplace with products that use Khronos standards
70 Companies creating media acceleration APIs
Khronos Participation Model

**Promoters**
- Board decides strategy - what APIs, budget, ratification of specifications. $15,000 annual membership dues

**Contributors**
- A Working Group for each API standard
- Conformance Tests and evaluation tools
- Conforming products can use API logo

**Ratified Specifications**
- Openly and publicly distributed – free of charge
- Free libraries, utilities, examples. Licensed for commercial use

**SDKs**
- Adopters

**Adopter Packages**
- Anyone can download specifications and SDKs and implement royalty-free products

**Implementers**
- Promoters

**Adopters**
- Any member can join working groups to produce specifications. $5,000 annual membership dues

Any member can join working groups to produce specifications. $5,000 annual membership dues

Adopters can use API logo

Conforming products can use API logo

Conformance Tests and evaluation tools

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A Working Group for each API standard

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Khronos Media Acceleration APIs

- Low-level APIs to harness graphics hardware acceleration
- Media Framework to control and synchronize multiple media streams
- Media framework interface and low-level primitives for media library operating systems and processor portability

Applications

Media Frameworks
E.g. OpenML, Symbian MDF, GStreamer, DirectShow, MMAPI

Graphics APIs
- OpenGL ES
  - 3D
  - Small footprint 3D Acceleration
- OpenVG
  - 2D
  - Vector Graphics Acceleration

Media Engines – CPUs, DSP, Hardware Accelerators etc.

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

Khronos APIs work together to enable an extensive media processing capability
Recent Khronos News

• Khronos membership 70+ companies
  - From all parts of the industry food chain

• OpenGL ES 1.1 publicly released on schedule in August 2004
  - To enable a new wave of 3D hardware accelerated cell phones

• OpenVG entering public review
  - Details on www.khronos.org

• First OpenGL ES hardware accelerated cell phones beginning to ship
  - Cell phone market is currently running at 500M handsets a year
  - Within 3 years there will be more OpenGL ES machines than Direct3D machines

The Nokia 6630 Symbian smartphone is now shipping and supports the OpenGL ES API

The Vodafone V602SH - With full hardware OpenGL ES acceleration – in stores in Japan now

First GIGA Class 3 phone with OpenGL ES

SK Telecom
P&C S3500
The Industry Standard for Embedded 3D Graphics
Increasing Cell Phone Functionality

- Mobile media capabilities sell more handsets

**VisionGain Report: Wireless Gaming 2002-2007:**
Currently 5M wireless game users in Europe - by 2005 this number is set to grow to an astonishing 130M

**IDC Report: US Wireless Gaming Forecast Update 2003-2008:**
Gaming will soon cross the chasm from early adopters to mass-market and grow to 34.7% of the US’ 190M users in 2008, resulting in 65M games players.

**Nov’02:** Nokia ships 50M imaging phones in ‘03
**Dec’03:** ALL NTT DoCoMo 3G phones have imaging

**Hundreds of Millions of Wireless Gaming Users? What will they Play? High quality 2D and 3D Graphics is Key**

**ARC Market Analysis 2003-2008:**
Over 40 cellular operators worldwide have launched mobile video services, thanks to technology advances, color screens, cameras, advanced media processors and increased memory storage....
Mobile Phone Market

Predictions

Millions of units shipped worldwide

- High-performance MM: CAGR 181%
- Basic MM phones: CAGR 68%
- Basic phones: CAGR -15%
Handheld Game Market

Sales of Games, Millions US$, per year worldwide
Jon Peddie Research

3D games
2D games

Predictions
Diverse Platforms Need 3D Graphics

Safety Critical

Avionics

Life-critical displays

Automotive

Line-powered Appliances

Consoles

Settop Boxes

Automotive console and heads-up displays

Entertainment solutions

Phones

PDAs

Hand-held Appliances

Advanced Personal Computing
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!!
OpenGL ES Requirements

- Cell phone industry is the first major adopter

- Hardware acceleration saves 90% of power

- Enable games to easily run on multiple platforms

- Low-cost chips and cores
  Complete software implementation at less than 50KB

- High-quality processing per pixel for small screens
OpenGL ES – Central to Mobile 3D

- Cross platform, low-level graphics API standard

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

Scenegraph APIs
M3G (JSR 184)
Games Engines
Middleware Libraries

Hardware OpenGL ES Engines

Software OpenGL ES Engines

J2ME
symbian
brew.
Windows Mobile

Operating Systems

High-level Graphics Libraries
Low-level 3D Graphics API

Applications

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**Fixed and Float Profiles**

- Support for high-volume devices systems with no floating point is key
  - But need to prevent fragmentation between fixed and float applications

- **Common-Lite profile replaces all floating point calls with fixed point**
  - Enabling applications to use just 16.16 integer math

- **Common Profile is a proper superset of Common-Lite**
  - Has BOTH fixed and float versions of all entry points

- **Common-Lite applications run without modification on Common Profile**

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Full functionality – but just fixed point entry points to API for integer-only platforms

Full functionality – with both float and fixed point entry points for code portability between profiles
EGL – Increasing 3D Code Portability

But operating system calls access platform resources - memory, processor threads etc. makes code non-portable

EGL abstracts graphics-related system resource calls – such as accessing screen windows. Makes 3D-related code cross-platform portable. Similar to GLX/AGL/WGL

OpenGL ES provides portable, cross platform, abstracted access to the 3D pipeline
Building the Graphics API Ecosystem

- All happening in “cell phone time”

Over 70 industry leaders are members of Khronos

Market demand for Handheld 3D

OpenGL ES 1.0 Conformance Tests released Jan’04. First conformant software and hardware already shipping

Enabling Developers

OpenGL ES 1.1 released Aug’04 – 12 months after OpenGL ES 1.0

OpenAPI Standards

Futuremark smart phone benchmark – uses OpenGL ES

Conformance Tests

Benchmarks

Great 3D Applications

First hardware accelerated OpenGL ES phones shipping in Summer 2004

High-quality platforms

Enabling Developers

OpenGL ES wins Game Developer Award for enabling ISVs

Open API Standards

OpenGL ES development tools and books on the market

Industry Cooperation

Over 70 industry leaders are members of Khronos

Futuremark smart phone benchmark – uses OpenGL ES
OpenGL ES Adopters Package

- Enabling Evaluation, Implementation and Testing

- Evaluate the API: fully operational OpenGL ES library
  - Includes full Gerbera™ executable for Windows from Hybrid

- Implementation Insights: open source sample implementation
  - OpenGL ES layered over desktop OpenGL on Windows and Linux

- Testing Functionality: source to Conformance Tests
  - Only Conformant products can use the OpenGL ES Trademark
  - A peer-review formal process raises the testing bar relative to desktop OpenGL

Reliable, cross-platform graphics functionality!

ISVs SHOULD DEMAND CONFORMANT PRODUCTS!
LOOK FOR THE LOGO!
Conformant OpenGL ES Products

• So far – many more in development
OpenGL ES in Action

Before OpenGL ES

Java MIDP1.0

MotoGP on Accelerated OpenGL ES

Nokia N-Gage

Increased visual quality, visual effects, screen resolution and frame rate – for less mW!!
OpenGL ES and EGL 1.1

• Enabling new-generation, hardware enabled handsets
• Delivered on schedule – enabling and encouraging industry progress
  - Khronos committed to annual API update at Siggraph last year
• Backwards compatible with OpenGL ES 1.0
  - A superset of OpenGL ES 1.0 - Common and Common-Lite profiles maintained
• OpenGL ES 1.1 Conformance Tests in three months
  - Formal peer review - sustaining API quality – vital for industry confidence and adoption
API Must Evolve at the Right Speed

- Not too fast to prevent widespread adoption
- Fast enough to encourage and expose new capabilities

- OpenGL ES 1.0
  3D running in software on CPU

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

- OpenGL ES 2.0
  3D shaders running on programmable hardware

Previous API generations continue to be used and deployed on diverse range of devices. OpenGL ES 2.0 does NOT obsolete OpenGL ES 1.0 and 1.1

Shipping Products
OpenGL ES Roadmap

• Update OpenGL ES every year by default
  - To expose rapidly developing handheld platforms capabilities

• BUT ONLY introduce features with proven demand from ISVs or IHVs
  - Guarding against unnecessary bloat

• Track and adapt developments in desktop OpenGL

Full high-level shading language capability to harness the power of programmable hardware

Widely available cross-platform 3D graphics API

Enabling software AND hardware implementations – including small-footprint, low-end fixed point platforms

State-of-the-art shader programmability for embedded devices

Increasing emphasis on enabling emerging fixed function 3D hardware

Mid-03  Mid-04  Mid-05
Safety Critical Profile

• Targeted at avionics and automotive applications
  - Enabling OpenGL ES drivers that can be DO178-B certified

• Khronos Safety Critical Working Group in progress now
  - To produce profile specification in first half of 2005

- Generic, minimum footprint, full function 3D enables diverse graphics applications
- Absolute minimum code size and complexity to ease safety certifications. Support for certified legacy applications
- SPEC IN REVIEW – if you are interested to be a reviewer email neil.trevett@3dlabs.com
- Some games functionality removed and display list functionality restored for legacy and auto-generated code
OpenGL ES Coding Challenge

• The OpenGL ES Coding contest is now running!
  - Sample code and applications for OpenGL ES games, demos and screensavers

• $100K in prizes to be awarded at GDC in March 2005
  - A license of dPVS, Hybrid Graphics visibility determination library (value $75,000)
  - Borland C++ BuilderX 1.5 Mobile Edition - courtesy of Nokia (value $8,000)
  - Subscription to JPR TechWatch (value $2,500)
  - 3Dlabs Wildcat Realizm board (value $1,500)
  - And more!

• See www.khronos.org/devu/opengles_challenge/
Strong Need for Vector Graphics

- Many applications need low-level vector graphics primitives
  - Portable Mapping and GPS applications, E-book Readers and text packages
  - Advanced user interfaces and screen savers

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

- OpenVG ACCELERATES existing formats – for the first time
  - NOT a competitor to existing formats

OpenVG can be called directly by 2D applications or by existing vector graphics packages
OpenVG – Accelerating 2D Graphics

- OpenVG is a low-level API for 2D Bezier-based vector graphics
  - With a focus on enabling hardware acceleration
- Vector graphics acceleration brings high value to handheld devices:

  - High-quality anti-aliasing for ultra-high-quality 2D graphics and text on small-screen devices
  - Accelerate vector 2D graphics for interactive performance
  - Provide SCALABLE 2D graphics for easy porting of content to different screen sizes
  - 2D graphics on hardware accelerators saves 90% of power
OpenVG Design Philosophy

• Provide a low-level hardware acceleration abstraction layer
• Place functions not expected in hardware in the near future into the optional VGU utility library
• Use OpenGL-style syntax where possible to make learning OpenVG as easy as possible for OpenGL developers
• Reference Path and Image objects by opaque handles - enabling hardware vendors to using their own preferred representations

Fast Track Development Schedule
OpenVG Feature Set

• Core API
  - Coordinate Systems and Transformations (Image drawing uses a 3x3 perspective (or projective) transformation matrix)
  - Paths
  - Images
  - Image Filters
  - Paint (gradient and pattern)
  - Blending and Masking

• The VGU Utility Library
  - Higher-level Geometric Primitives
  - Image Warping
  - Animations
Media Library
Portability
Complete Media Library Portability

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

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

Application

Operating System Media Framework

IL – “Integration Level”
Media Primitives – provide portability to different operating systems

MP3 | AMR | H.264 | MPEG4 | More Media Libraries

OpenMAX Media Engines
CPUs, DSP, Hardware Accelerators etc.

DL – “Development Level”
Media Primitives – provide portability of silicon acceleration

Wide range of video codecs, image and sound libraries etc.
OpenMAX – Media Primitives

• Combinatorial problem of hardware and software
  - Media libraries are typically LATE to market and POORLY optimized

• OpenMAX defines standard collections of media “hotspot” primitives
  - To be implemented on multiple processors, platforms and architectures

• Enables rapid PORTING and OPTIMIZATION of multimedia libraries
  - Video, audio, graphics, imaging etc.

A wide range of media acceleration silicon using many diverse architectures

Silicon vendors supply optimized OpenMAX libraries for rapid porting of libraries across multiple accelerators

An increasing number of multimedia API libraries for video, audio, graphics and images
OpenMAX Technical Sub-groups

- Market segment focused technical sub-groups
  - Coordinated under a single working group
  - Chairperson for each sub-group

- Video DL
  - Kathy Moseler
  - Motorola
  - MPEG-4 SP / H.263 BL (encode & decode)
  - H.264 (decode)
  - JPEG encode and decode, Color space conversion, packing/unpacking, De-blocking / de-ringing, Camera processing, Simple rotation and scaling

- Still Image DL
  - Hedley Francis
  - ARM
  - Integration with Symbian MDF, GStreamer, DirectShow, MMAPI media frameworks

- IL
  - Richard Baker
  - TI

- Speech / Audio
  - Mark Kokes
  - Nokia
  - MP3 and AAC, AMR-WB and AMR-NB for Mobile Phones, Portable Media Players and MP3 Players
OpenMAX Working Group

- Specification will be open and royalty-free
  - Using Khronos reciprocal licensing IP model
- Creating complete set of deliverables
  - Specifications, implementations, conformance tests
- Available on wide variety of architectures and operating systems
  - To enable true media library portability
- Encourage wide industry support and adoption
  - Khronos strongly committed to promote this important new standard

2Q04
OpenMAX Working group established. Public announcement to invite industry participation

3Q04
1st OpenMAX face-to-face meeting

4Q04
Draft OpenMAX 1.0 specification completed

1Q05
Ratify and publicly release OpenMAX 1.0 Initial implementations available

2Q05
Further Resources

• **www.khronos.org**
  - All presentations posted there

• **Public Forums**
  - Get involved in the Khronos community

• **Specification Reviews**
  - Sign-up for mailing list alerts for API draft reviews

• **DevU courses around the world**
  - Free full day educational courses
  - Details on [www.khronos.org/devu/index.html](http://www.khronos.org/devu/index.html)

• We welcome enquiries from companies interested to join Khronos
Any Questions?