

“Processor Graphics”

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My Brief History

- I started at General Electric in 1978
 - Flight Simulators \$10M each
 - Sold by the pound
 - Short list of 1st's:
 - Procedural textures (1978)
 - Bitmap Textures – Tri-linear Filtered (1983)
 - Tile Based Deferred Rendering (1986)
 - Z Buffered Real-time Rendering (1986)
 - 16X MSAA Antialiasing (Color and Z) (1986)
 - Geometry Tessellation (1986)
 - Then there was Intel740[®] Graphics Accelerator

Short History of Graphics at Intel

- Intel 740 - Initially started as a joint venture with Real3D (Derived from General Electric's Flight Simulator business)
- Original intention was to create a discrete graphics business
 - Got redirected to Chipset Integrated
 - White Space
 - Intended for Business users, Mom and Pop
 - Not Gamers – OK, maybe casual gamers (WOW)

What Changed: Visual User Experiences - Exploding

Vastly Richer Displays

High dpi, touch, Stereo3D, wide
Draw more, richer pixels

New Gfx Usages

HTML5 makes Web 3D
Advanced User Interface
Realistic 3D gaming

Traditional Media

Transcode, LP Media, HQ Video
Conferencing, 4k Media, HEVC

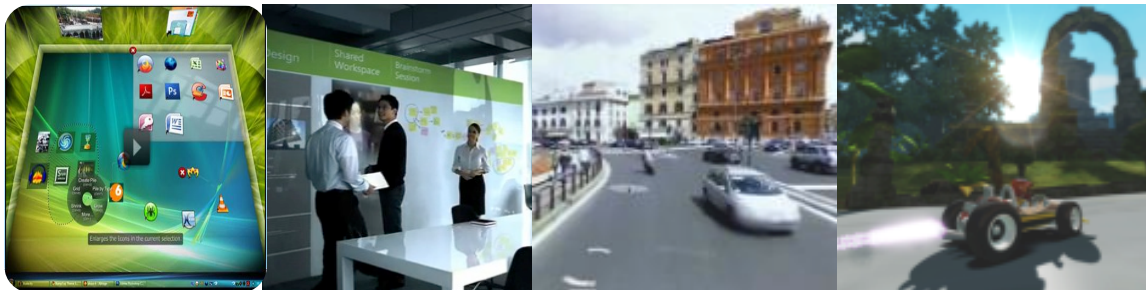
GFLOPs-based Media

Video Processing & Analytics
Computational photography

Comp & Environment

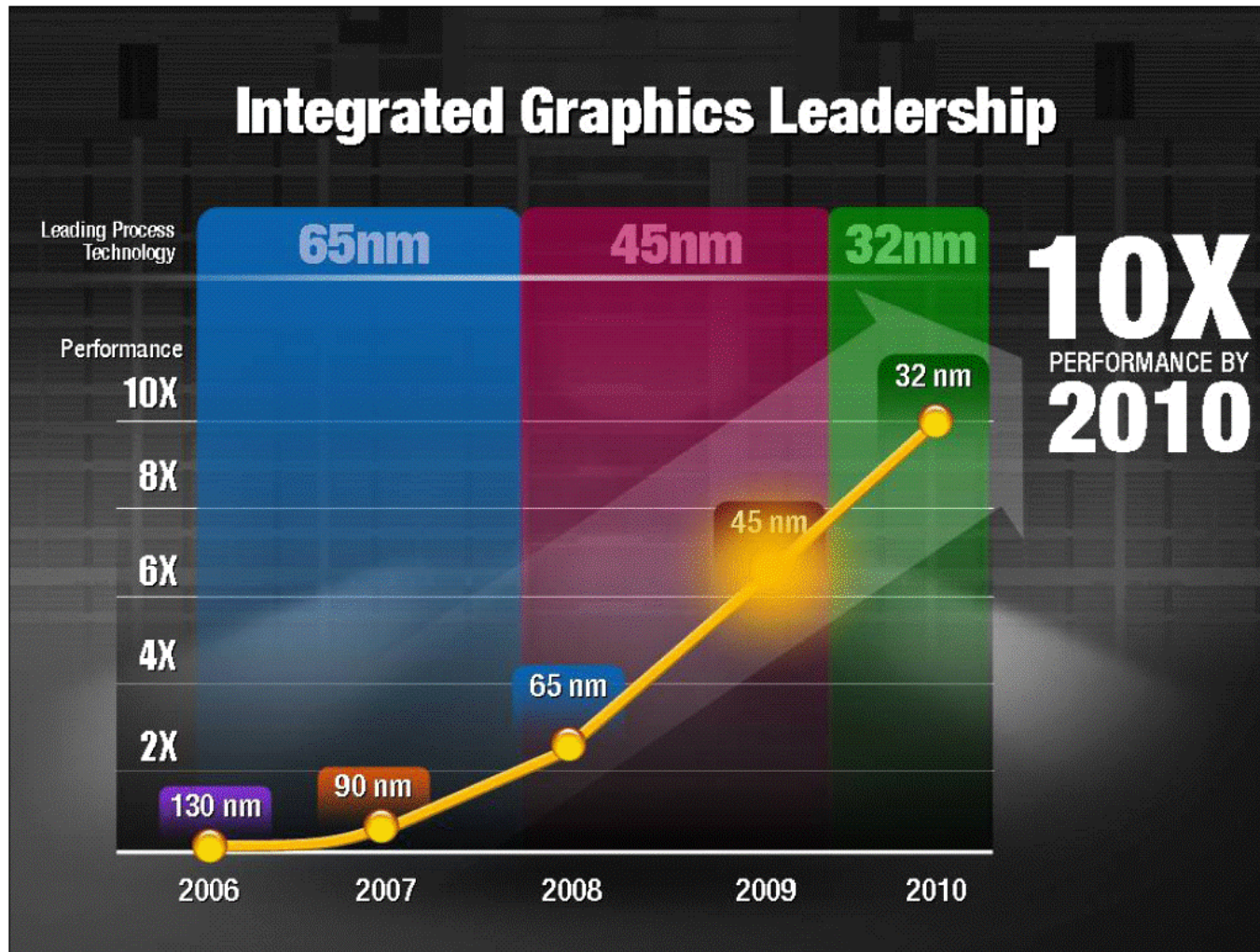
Competition investing in big Gfx
Apple: Big Gfx iMac, MBP, MBA
Android: GPU > important vs CPU
Win8 Metro: new min Gfx bar
Next-gen Consoles est in '13
Hetero CPU+Gfx Programming

***pGfx Arch Wins in Thin Form Factor
Scales up in Perf - \$6.5B dGfx SAM***



Visual Computing Central to New User Experience
PC expectations are now the expectations of a Tablet (Ease of Use) with the UI of a PC (Keyboard, Mouse)

What we said ... and then ...



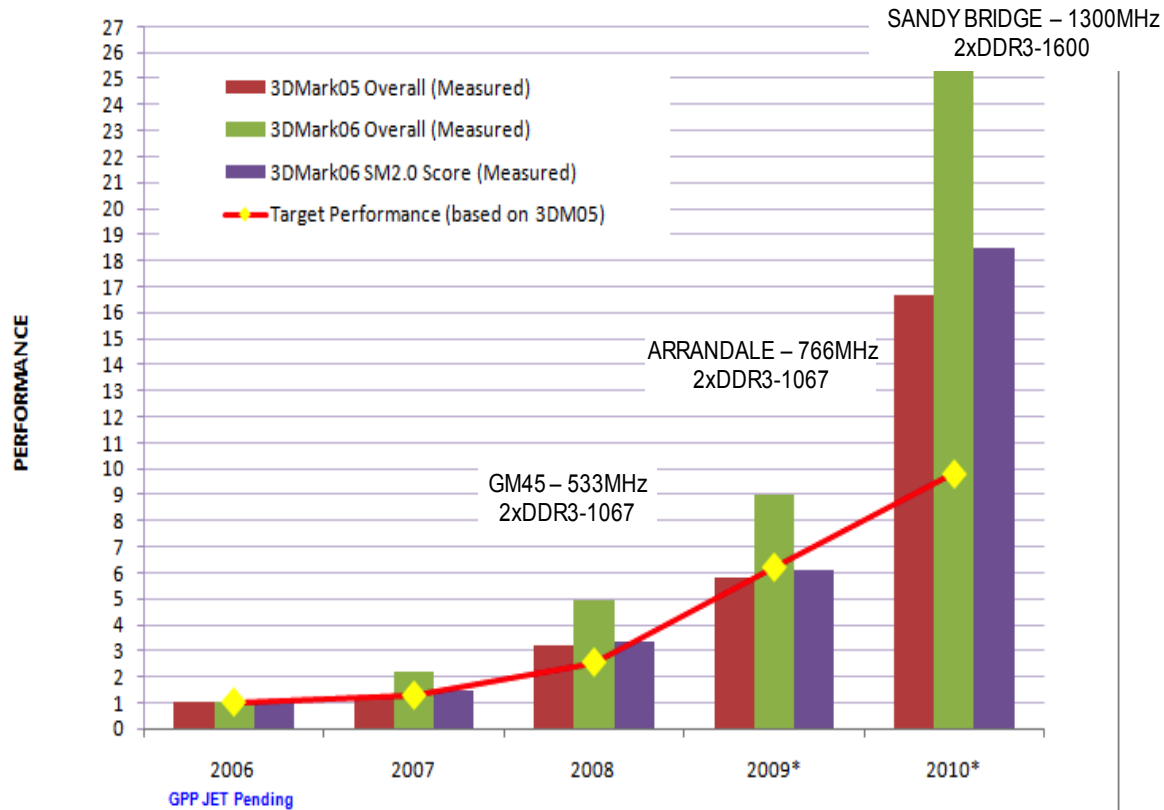
... what we delivered:

Processor Graphics – Sandybridge

- Sandybridge is 1st incarnation (2010)
 - Cache sharing (sets a stage 😊)
 - Power Sharing – Voltage and MHZ modulated
 - CPU Hi, Gfx Lo workload → Power to CPU
 - CPU Lo, Gfx Hi workload → Power to GPU
 - DX10.1
 - OpenGL3.0 at initial release, OpenGL3.1 on present release

Sandybridge Exceeds 10X by '10 Goal

Mobile Mainstream Competitive Performance



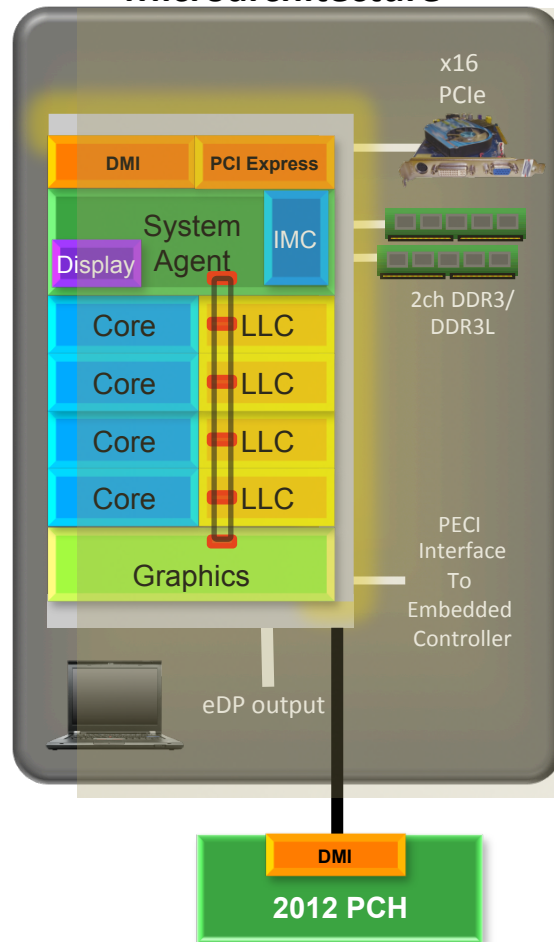
Assumes PRQ dates. SNB config: 2.8GHz 4+2 8MB LLC shared 1300MHz Core and 2xDDR3-1600. 3DMark05 is used since 3DMark2006 has a SM3.0 test that does not run on 2006 parts. 3DMark2006 SM2.0 sub-test is shown since Gen driver optimizations for all recent devices are not focused on 3DMark2005.

Processor Graphics – Ivybridge

- Ivybridge is 2nd incarnation (2011)
 - Same power and cache sharing
 - DX11
 - OCL1.2 - OpenGL3.3 at initial release
- Performance wise, Ivybridge is basically an XBox360 on every laptop

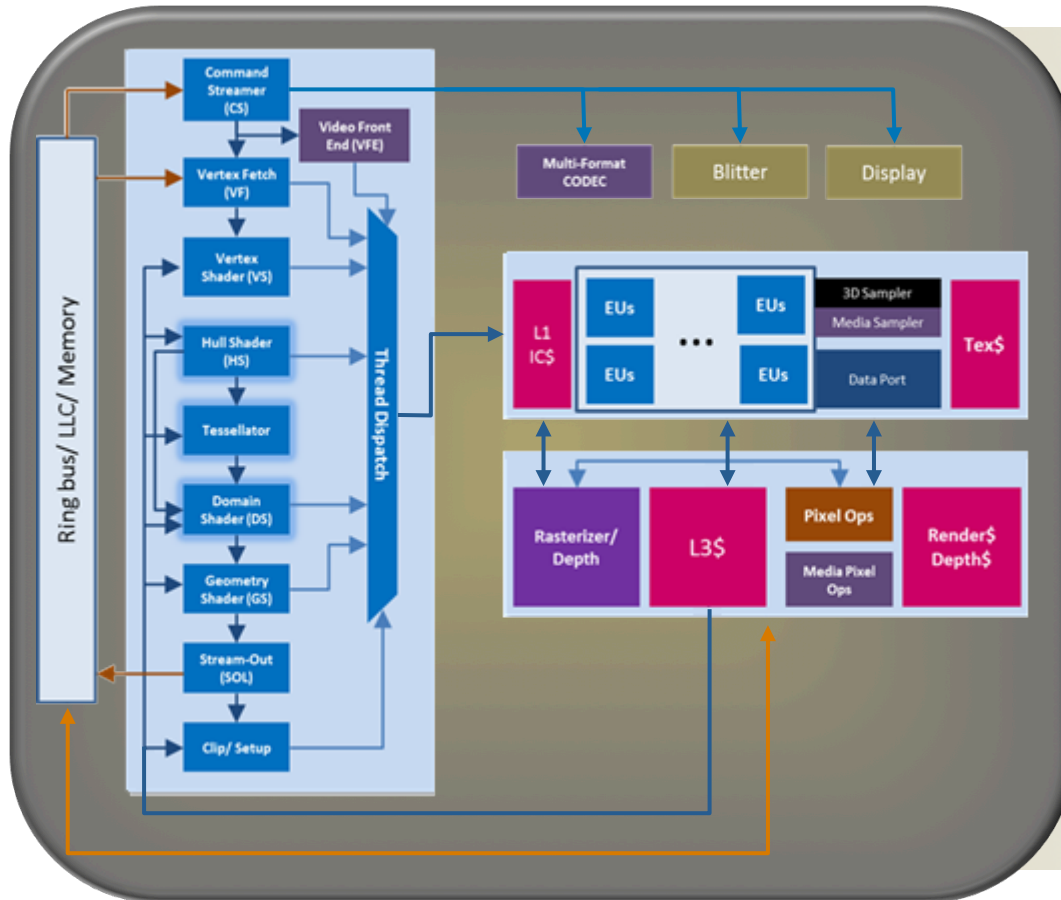
Ivy Bridge Graphics and Media Microarchitecture Overview

Ivy Bridge Microarchitecture



- Next generation Intel® Core™ microprocessor on the latest 22-nm process
- Improved Game Playability
 - More 3D performance
 - Microsoft* DirectX*11 Support
- Significant Media Performance
 - Higher performing Intel® Quick Sync Video
- Three Native Display Support

Ivy Bridge HD Graphics: mArchitecture



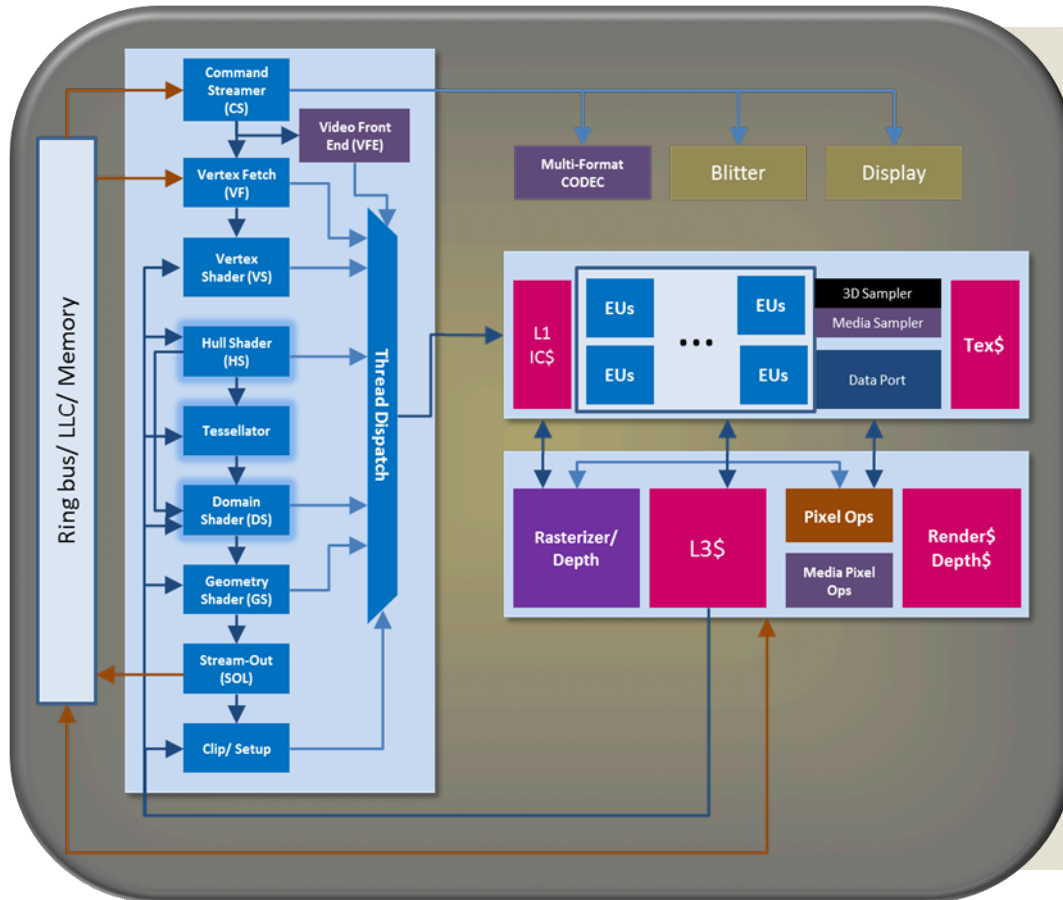
μArchitecture Changes

Scalable Architecture partitioned into 5 domains:

1. Global Assets: Includes Geometry Front-end up to Setup
2. Slice Common: Includes Rasterizer, L3\$ and Pixel Back-end
3. Slice: Shaders (EUs), IC\$, Samplers, Addr Gen
4. CODEX and media
5. Displays

Sets the stage for further scale-up opportunities

Ivy Bridge HD Graphics: Architecture



Adds Significant 3D Enhancements

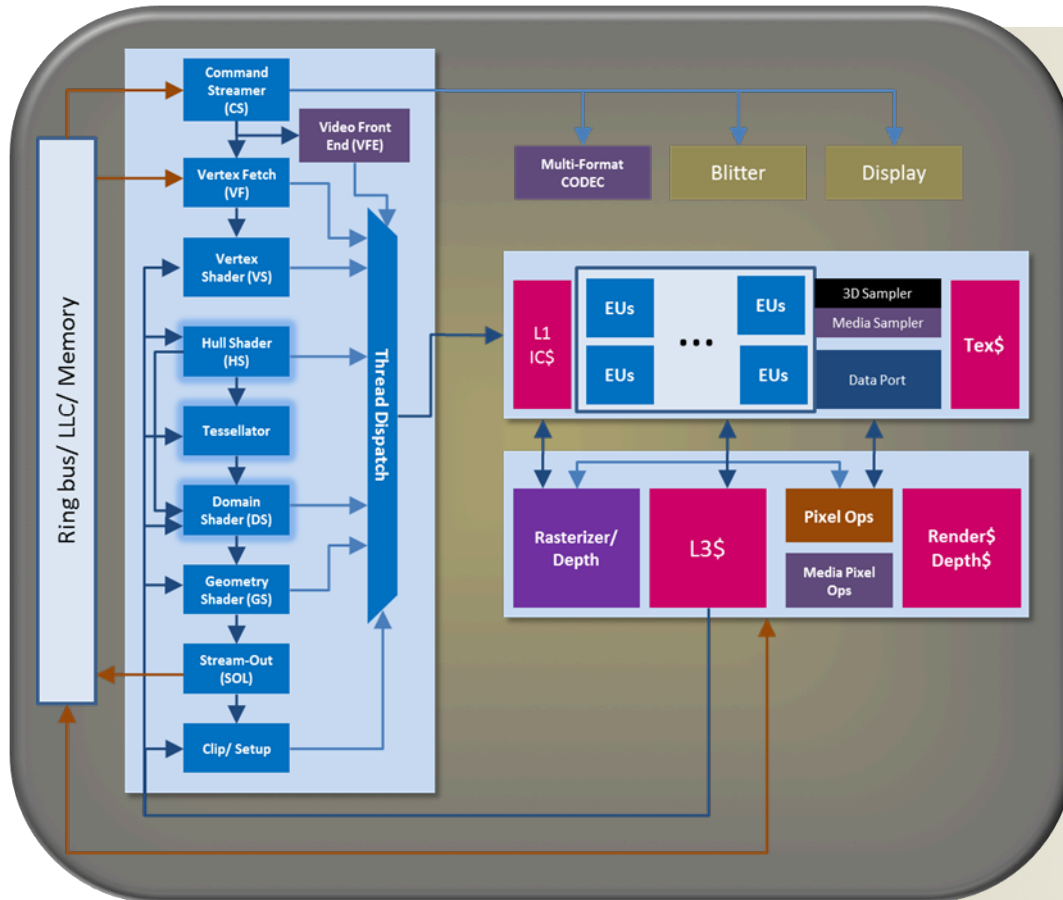
Microsoft* DirectX* 11

Hardware Tessellation

- Adds two programmable stages (HS and DS) and one fixed function Tessellator

New Compressed Texture Format Support (BC6H/7)

Ivy Bridge HD Graphics: Architecture



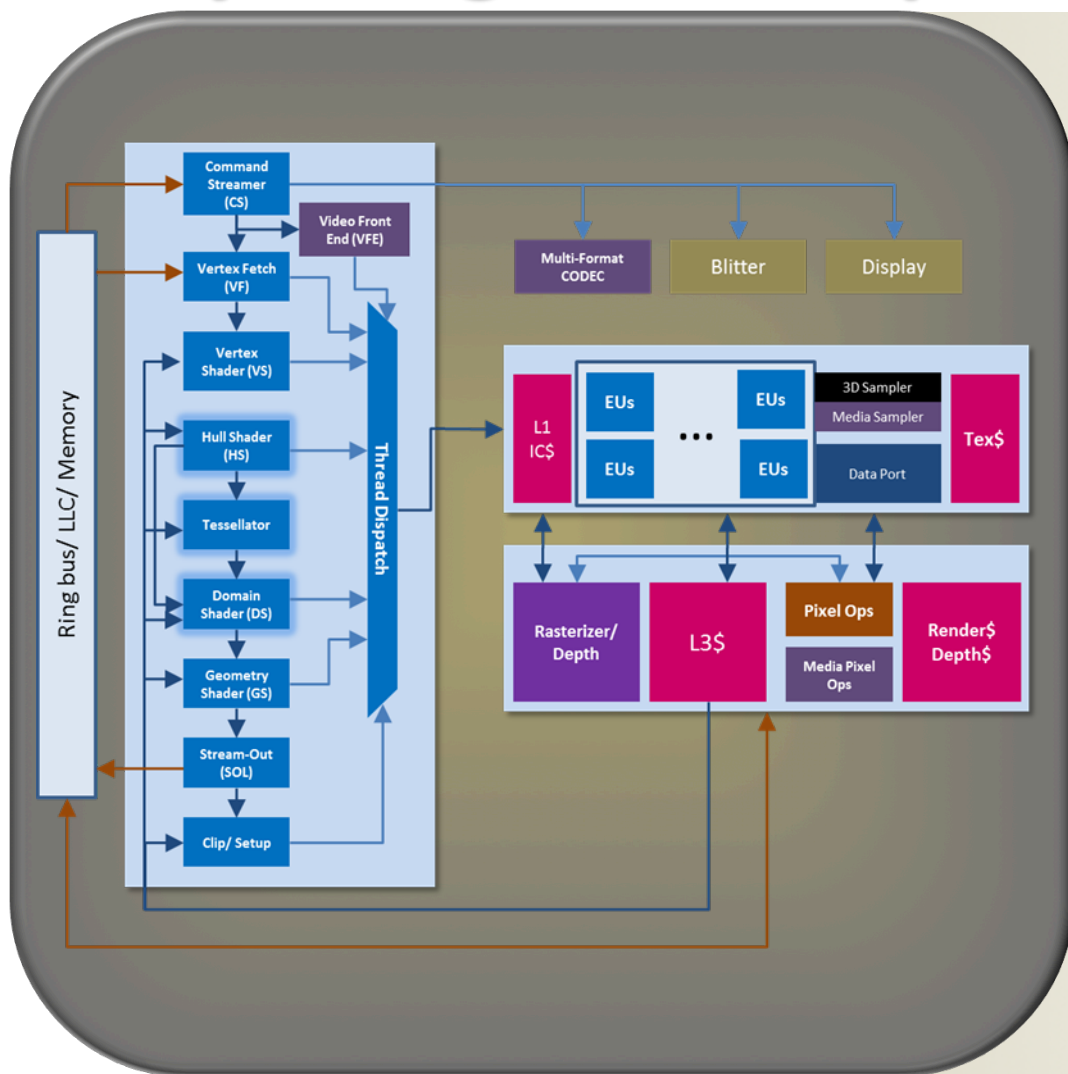
More Key Changes

Compute Shader Support

- Data Parallelism
- UAVs, Atomics, Barriers, etc for compute shader ops
- Shared Local Memory aka Thread Group Local Memory for Direct Compute* Shaders
- Scatter gather

Shader Array adds support for Shader Model 5.0 (New DX11 Instructions)

Ivy Bridge HD Graphics: mArchitecture



μArchitecture Changes

Improved Geometry Performance

- Faster GS and H/w Stream-out
- Faster Clip/Setup

Fast Clear of Render Target

Increase in Hi-Z Performance

Sampler throughput

- Improved Anisotropic Quality

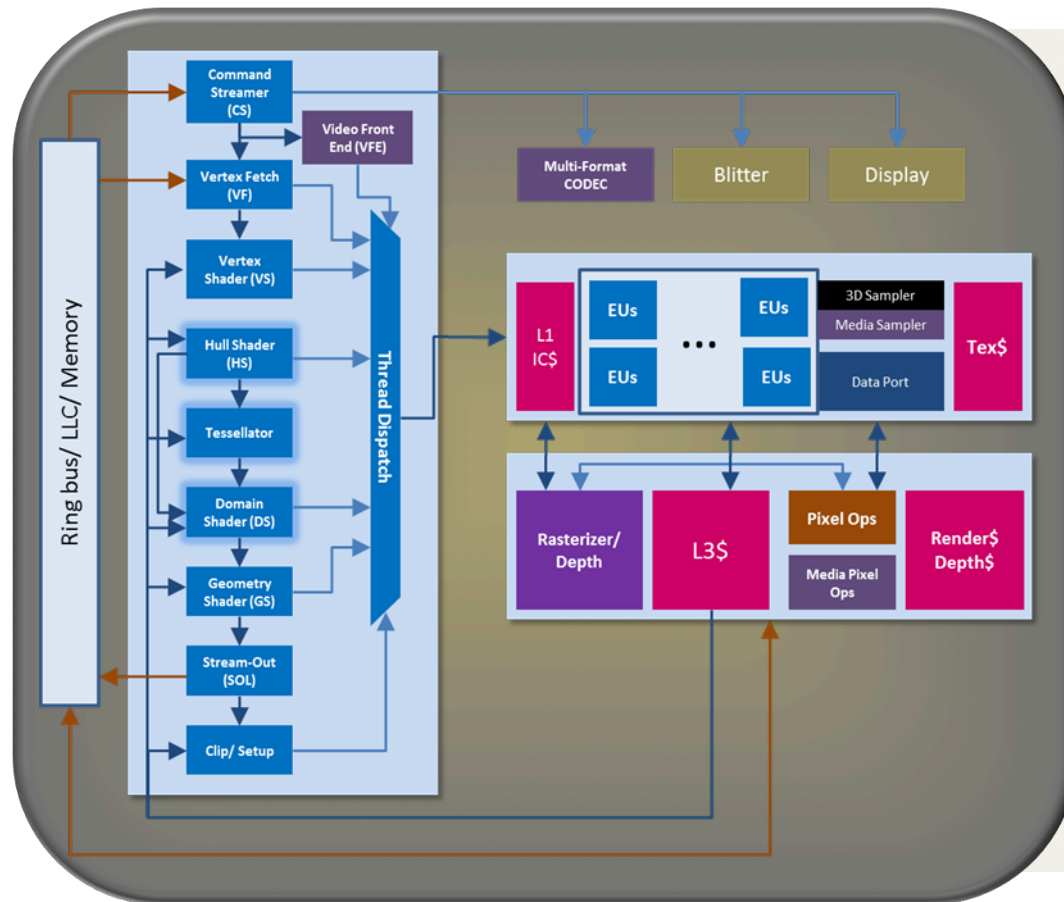
Increased compute throughput (peak GFLOPs)

- Increased # of threads/registers to cover latency and support complex shaders
- “Enhanced” coissue

L3\$ lowers BW need from Ring Architecture

Media Applications benefit from infrastructure changes in EU/L3\$/etc

Ivy Bridge HD Graphics: mArchitecture



Significant Media Performance

- Higher performing Intel® Quick Sync Video

μArchitecture Changes

- Enhanced Performance for Multi-Format CODEC
- Increased Media Sampler Throughput and performance for scaling and other filters
- Pixel Back end has Image Color and Contrast Enhancement capabilities

Processor Graphics Future Goals

- Maximize performance attainable within specific “socket” limits
 - 25Watt Laptops
 - 15Watt Thin and Light “Ultra-Books”
 - 3-5Watt Tablets and Phones

How do we do this?

- Most efficient operating point of anything in silicon is at the knee of the process:
 - Power = $C * V^2 * F$
 - Max Frequency allowed at V_{min} since Voltage has a squared power function (cubic when leakage is factored in)
- Future products will have sustained power limits at V_{min}
 - Higher power in “bursts” if Silicon is “cold”

Summary

- Intel® Next Generation Microarchitecture, Codename Ivy Bridge, is the 1st product on 22 nm process technology
- Another big leap in Performance/Power efficiency in both IA core and Graphics/Media
- Features for improved Security, better Battery life, new Memory technology (DDR3L), better Overclocking support
- Next generation Graphics microarchitecture is a Significant Graphics and Media (“tick+”) evolution for Intel® HD Graphics

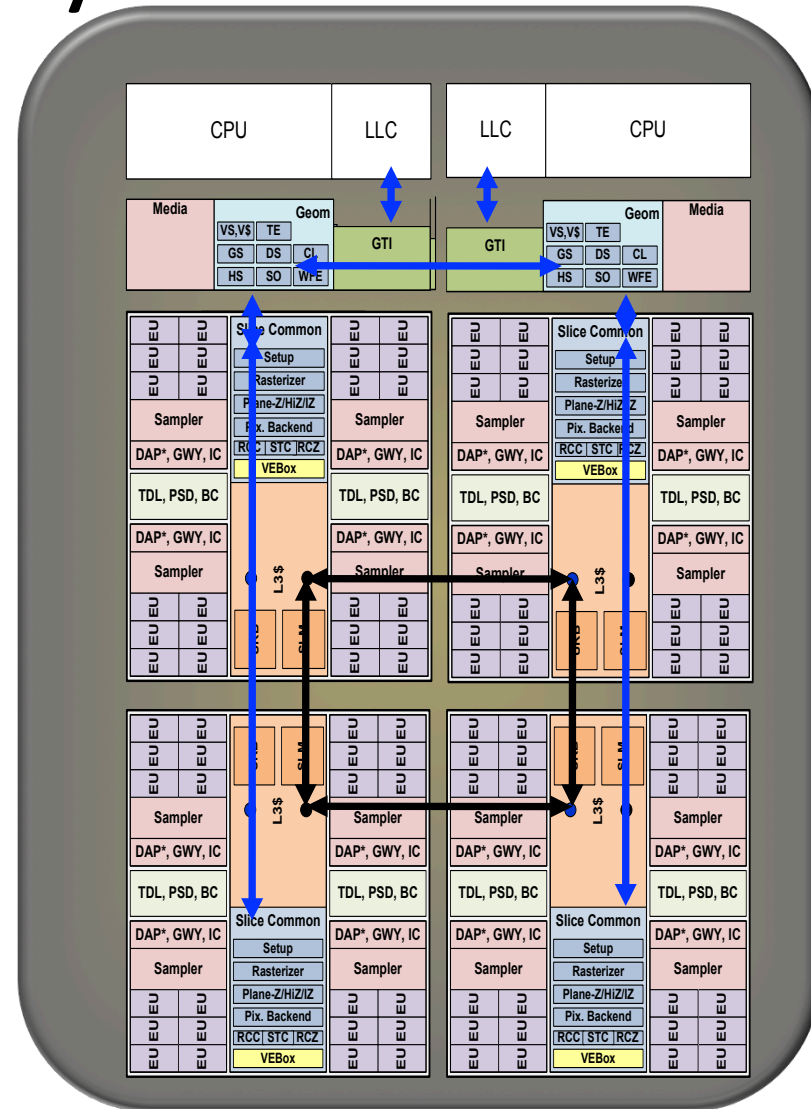
It's Just The Beginning...

Some Metrics

	Sandybridge	Ivybridge	Next
Max Ghz	1.3	1.2	1.X
Shaders	12	16	Much More
MAD / Clk	4	8	8
Plane / Clk	4	4	4
Max Gflops (Plane+MAD)	250	461	Much More
Max Gflops (MAD+MAD)	125	307	Much More
Samplers @ 4 Texels / Clk	1	2	Much More
Scatter/Gather / Clk	1	32	Much More
DX Rev	10.1	11	
OGL Rev	3.0	3.3	
OCL Rev	NA	1.2	

Scalability – GenX

- “Slice” Based
- At 1GHZ, provides 2 TFLOP of shader performance (GT4)
- Chop:
 - Slice Half – GT1
 - Right Half – GT2
 - Bottom Half – GT3



Conclusion

- Intel is committed to a comprehensive graphics roadmap:
 - Maximum performance on “Battery” driven platforms:
 - Laptops → Tablets → Phones
- Always looking for talent
 - Many Geographies
 - The sun never sets on Intel 😊

Q & A