
PS4™

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UNLOCKING THE POTENTIAL OF PLAYSTATION®4: AN IN-DEPTH DEVELOPER GUIDE

Sébastien Schertenleib, Senior Principal Engineer
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1	PlayStation®4 Hardware Overview
2	User Experience
3	Graphics On PS4™
4	Development Environment

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PlayStation®4

Designed to be the Ultimate Gaming Platform

- Next Gen Hardware
  - Central device in the living room
  - Powerful game machine
  - Innovative input experiences

- Next Gen Network Services
  - Frictionless access to content
  - Connected on standby
  - Connect to PS®Vita, tablets, phones
  - Simultaneous digital launch

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Many Options, One Decision

- To meet these goals, we opted for a streamlined, orthodox architecture – to reduce complexity for developers
  - Familiar CPU and GPU
  - Unified memory
  - Hard Disk in all models

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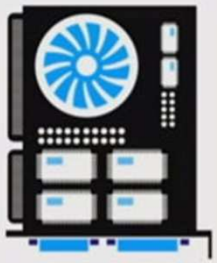
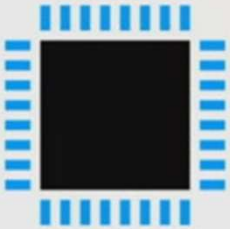
Developer Input

- Input from internal as well as external studios
  - Hardware – CPU and GPU
  - Software – Libraries and API design and implementation
  - Tools – design and implementation
- Developed from the ground up with developers in mind
- Created by developers for developers

INFORMED SYSTEM ARCHITECTURE



SUPERCHARGED PC ARCHITECTURE



X86 CPU

ENHANCED PC GPU

8 GB UNIFIED MEMORY

LOCAL STORAGE HDD

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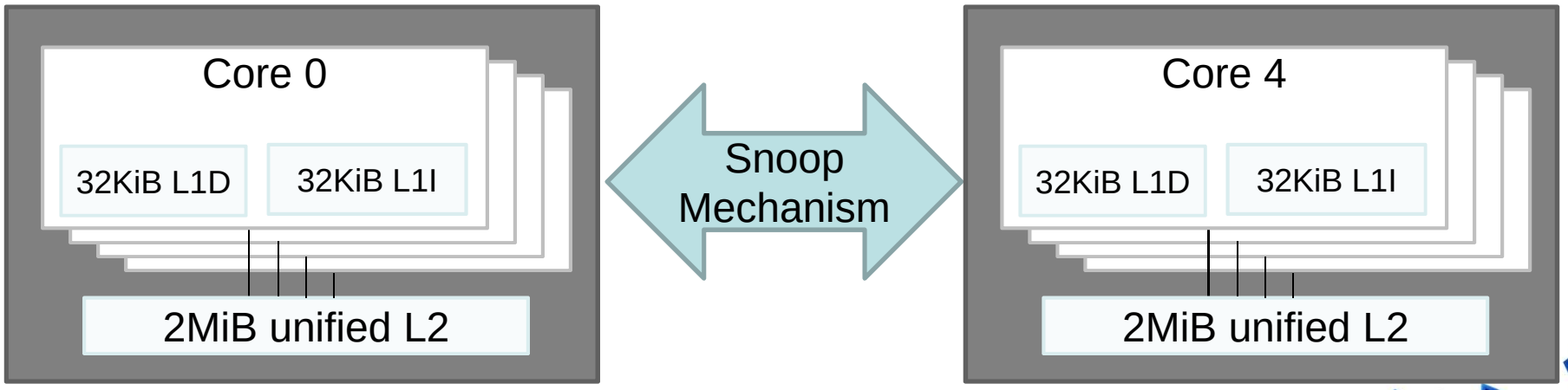
“Jaguar” CPU Cores

- Jaguar: state of the art low-power x86-64 CPU core
- PS4™ contains 8 Jaguar cores
  - Arranged as two CPCs (“Core plus cache”)
  - Each contains 4 cores and a shared 2 MiB L2 cache



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Architectural Overview

- Key Points
  - Advanced ISA, support SSE4.2 and AVX
  - Out of Order Execution and Register Renaming
  - Multiple levels of branch prediction
  - 128-bit SIMD ALUs
  - 2MiB L2 cache per cluster → 512KiB per core if evenly distributed

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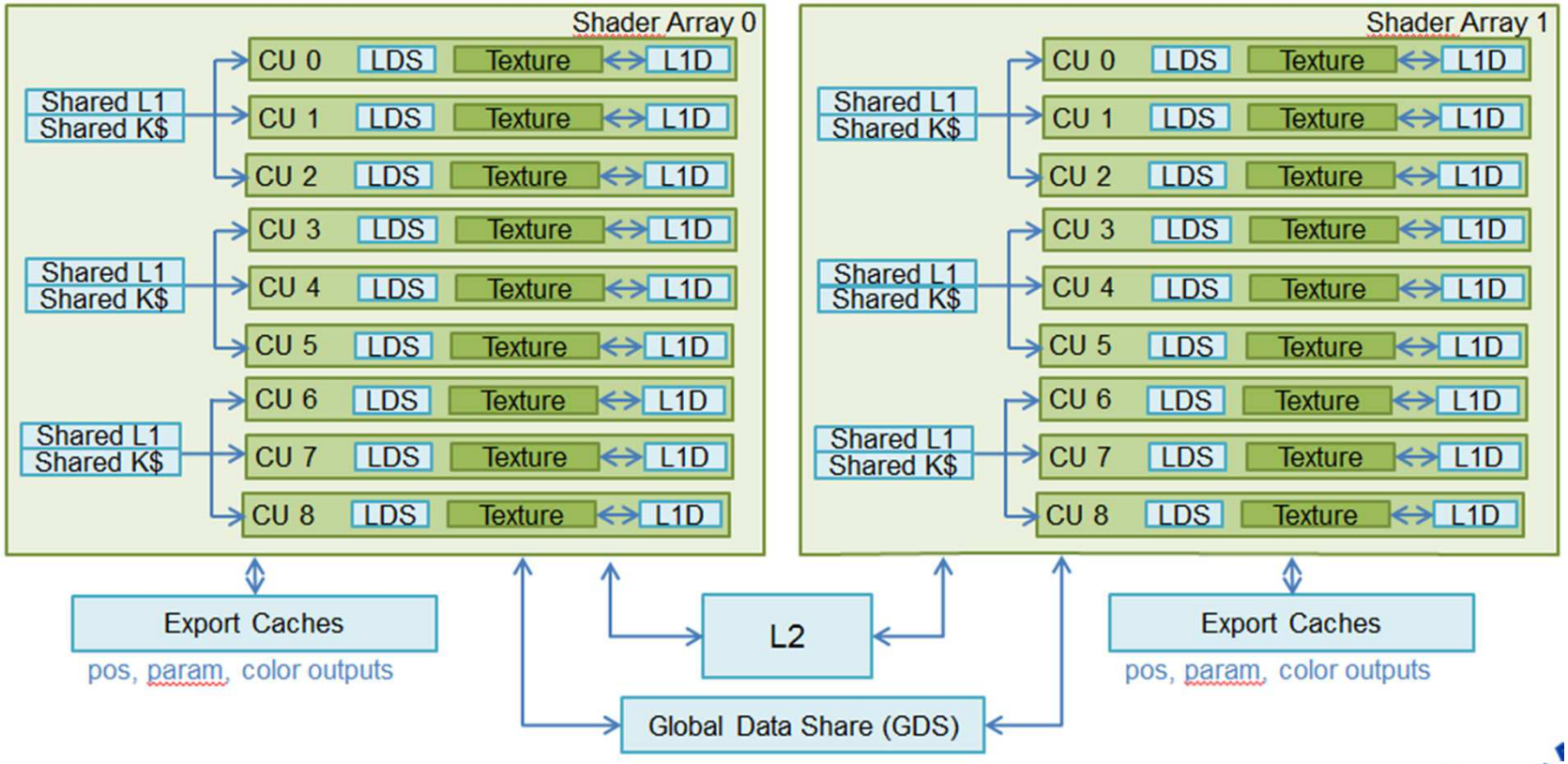
GPU: 1.84 Tflops, AMD Radeon™



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Reducing Bottlenecks (1/2)

- Memory Bottleneck:
  - Often the first graphics bottleneck is memory bandwidth
    - Lots of stages of the graphics pipeline can suffer from this
    - Lots of large textures per object
    - Don’t want to drop bits per texel
- Solution:
  - Have very high bandwidth 256 bit GDDR5 RAM
  - 176 GB/s total bandwidth
  - Over twice as fast as DDR3

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CPU and GPU Bandwidth Interaction

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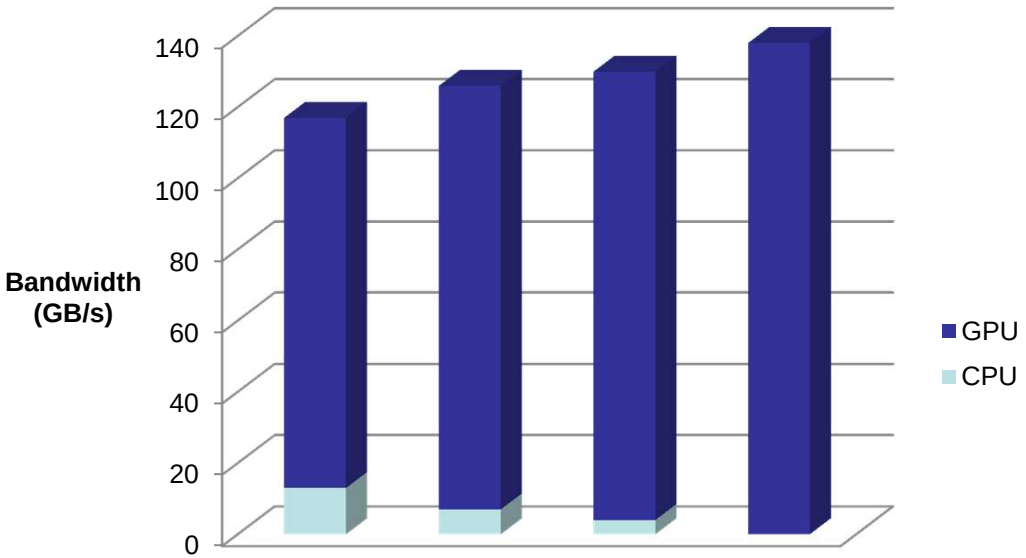

CPU bandwidth reduces GPU bandwidth disproportionately

Reducing Bottlenecks (2/2)

- Fillrate Bottleneck
  - Shadow or particle system require high fillrate
  - Super fast RAM performance gets wasted without fillrate
- Solution:
  - Make sure HW has enough Render Back End units
  - Pixel fill rate on PS4™ is greater than the memory bandwidth

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GPU+RAM+CPU = Beyond Fast!

- True Next Gen Game Experience
  - 8 CPU cores
  - High polygon throughput
  - High pixel performance

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DUALSHOCK®4

- Familiar controls with several key improvements
  - Dual analogue sticks and trigger buttons
  - Higher control on the motors (vibration) and motion sensors

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SHARE


SHARP

Speaker

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Headset-mic jack

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Light Bar

- The camera continuously tracks all four controllers with precise accuracy
- Rotational tracking provided by accelerometers + gyros
- RGB LED
  - Gameplay feedback

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PlayStation® Camera

Super Wide Angle Stereoscopic Dual Camera
Each camera can be individually configured (resolution, frame rate, exposure, gain, white…)

Max Resolution
1280x800 (8:5)

H/W Output Format
Raw8/Raw16(HD only)
YUV422
Y8/Y16(SD only)

Frame rate (max)
60fps@1280x800
120fps@640x400

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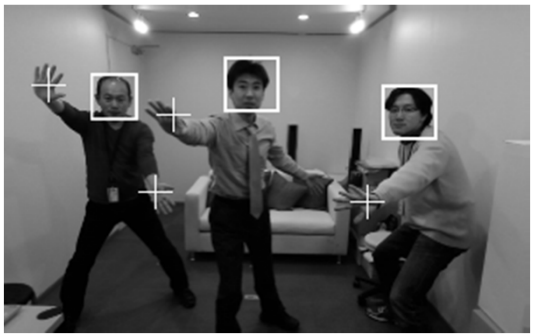
Depth From Triangulation

- Stereo depth map computed in software




KNACK
Start
Invite Friends
Over View
Friends Who Own This 3
Trophies 2
New Feeds 12
Shared Media 6
KNACK
Sony Computer Entertainment
Overview
Most viewed video
KNACK
Emerald Relic
Gift from a Friend
Sunstone
Got a rare item !
Friends Who Own This
more
Trophies
+4
+2
more
Enter

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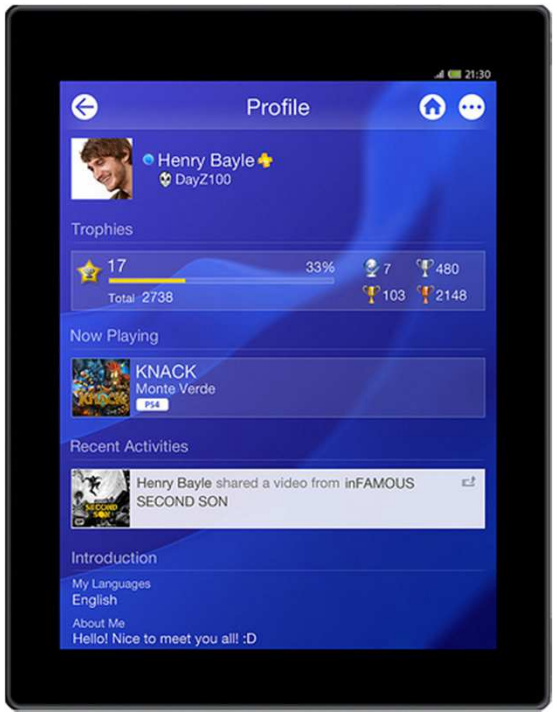
PlayStation®App



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Game Companion Apps

Your dedicated game or franchise application for iOS or Android

Expanding the PS4™ experience into user's everyday life

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Remote Play

- Transform the Playstation®Vita into the ultimate companion devices for PS4™
  - Remapping of buttons
- Connect over Wi-Fi access point in local area network
  - Ensure low latency

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Play As You Download

- Players can start the game quickly after game purchase
  - The game data will be split into multiple chunks
  - Players can start playing when the minimum amount of data has been downloaded
- PS4™ can continue downloading while in stand-by

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Store

Select Download Priority

Please select which part of the game you'd like to play first. The rest of the game will continue to download in the background.

KILLZONE
SHADOW FALL

Download Multi-player Mode First
Fight your enemies online, and be the hero amongst your friends.

Download Single-player Mode First
Maintain the fragile peace, before the conflict spirals out of control taking your homeworld with it.

Overview
Activity Feed 7
Related 12

racing to cycle your camera through the available driving views, including the immersive cockpit view. Racing at 100mph from behind the steering wheel lets you experience racing from a whole new perspective.

Enter Back OPTIONS Privacy Policy & Terms of Service

Will Walker

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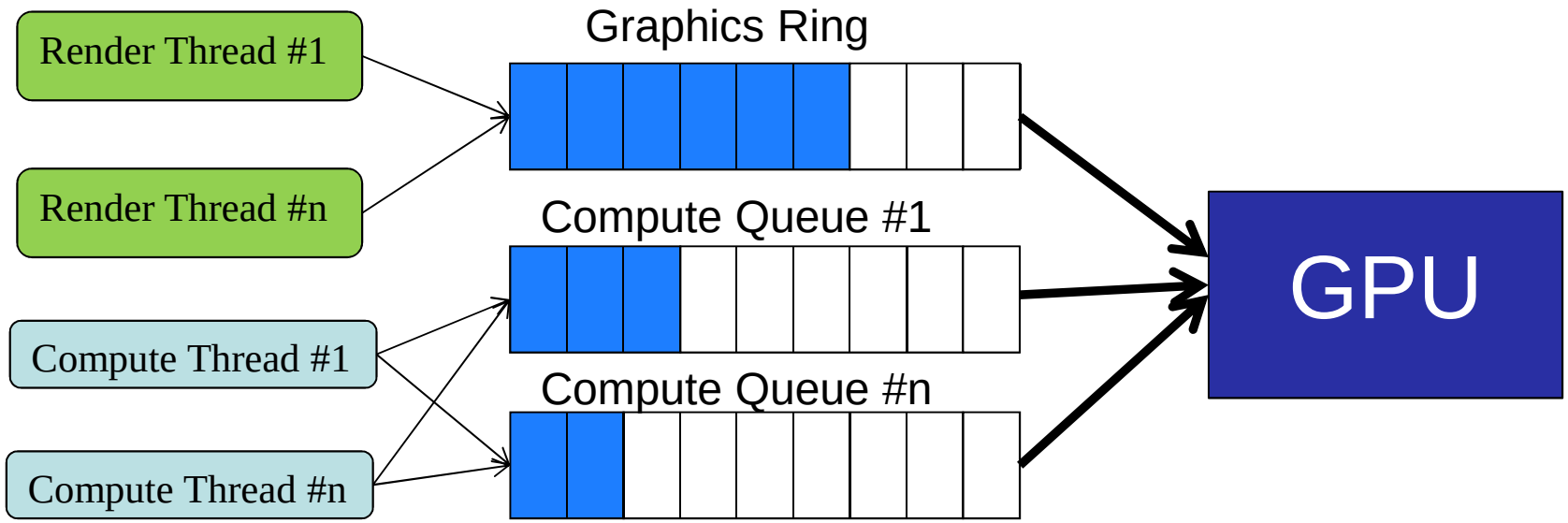
Developer Experience

- Low level Graphics API (GNM)
  - Builds directly command buffers to feed to the GPU
  - Resembles DirectX and OpenGL without sacrificing efficiency
  - Pre-build and reuse data structure as much as possible
  - Application is in charge of memory management
  - Synchronization primitives
  - Enhanced performance by bypassing costly DirectX limitations and bottlenecks

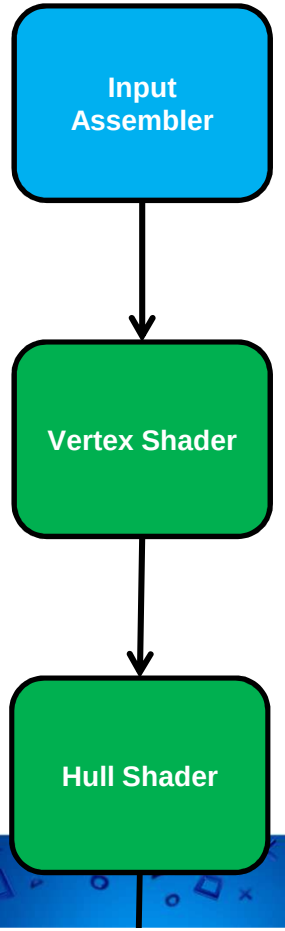
Multithreaded CPU Rendering

- Can use independent threads



Beyond PC with PSSL on PS4™

- Greatly expanded shader pipeline
  - Geometry and tessellation shaders
  - More direct exposure to shader stages than DirectX
- Extended Buffer Support for all shader stage
  - RW_Textures and Atomics



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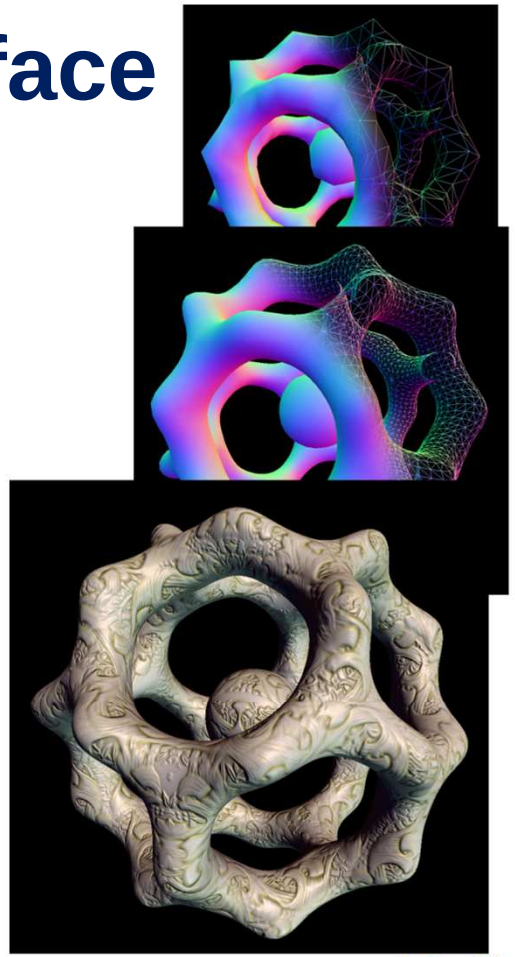
Subdivision Surface

- Supports special cases GS like
  - GS Tessellation
  - Instancing
  - Cube mapping
  - Streamout
- Supports HS DS Tessellation
  - Parametric surface conversion
  - Optimal Geometry generation



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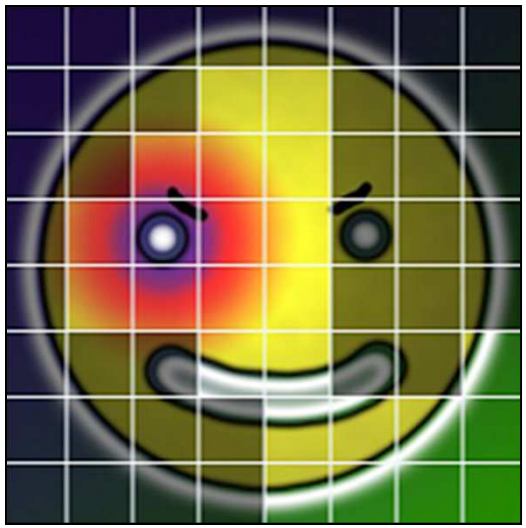
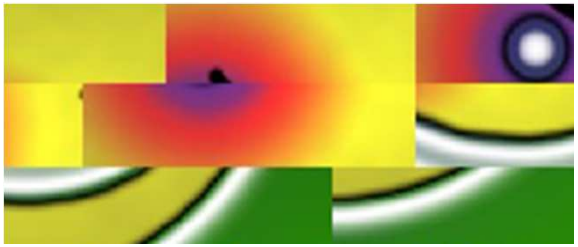
Partially Resident Texture



Virtual Texture



Physical Representation

Compute Shader

- Full support
  - Parallel Multithreaded execution
  - This cross wave and group synchronization primitives like barriers and atomics
  - Various Local and Global memory

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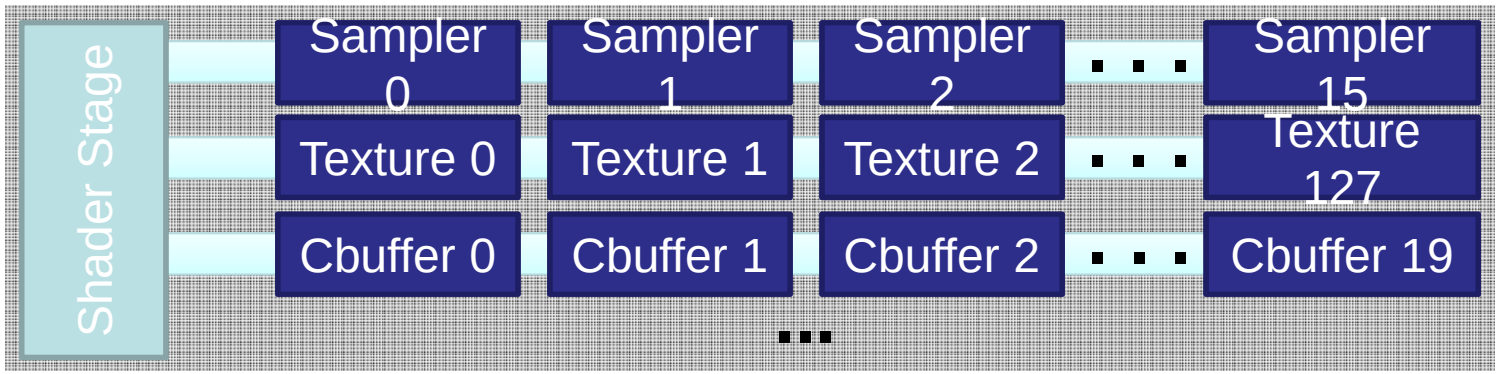
Traditional Data Binding



Texture A | Texture B | Sampler A | Sampler B | CBuffer A

Shader Resource Tables

- Shader Resource Tables (SRTs) place control of the shader resource layout into users' hands
  - Users know which resources change frequently vs. which are static
  - Users specify the layout and manage resources to maximize reuse between draw calls

Resource Layout

User Data	
[0:1]	Extended User Data*
[2:3]	Extended User Data*
…	…
[14:15]	Extended User Data*

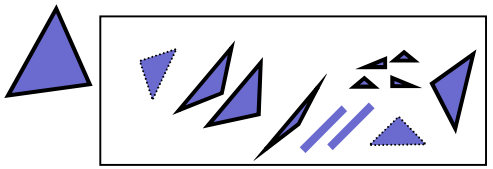
Extended User Data 0	
[0:15]	float4x4 modelMatrix

Extended User Data 1	
[0:2]	float3 lightDirection
[3:5]	float3 lightColor
[6:21]	float4x4 viewProjection

Extended User Data 7	
[0:3]	float4 matColor
[4:4]	float intensity

DispatchDraw: Index Culling

- Triangle culling in a CS frontend to an existing vertex shader
  - No shader code changes required
  - Uses a custom segmented index data format as input, with conversion code provided
  - Culls back-facing and off-screen triangles, and indices not used by any surviving triangle
    - Up to *70%* of triangles do not contribute to final image



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Asynchronous Compute on PS4™

- Most PC graphics hardware
  - Requires graphics processing to stop to perform Compute
- PS4™
  - Allows compute tasks to execute in parallel with graphics
- Full access to unified memory
  - Compute and CPU tasks can work on the same data
- *We expect in a couple of years asynchronous compute will be a big part of game tech*
  - Dozens of programs running at the same time on GPU
  - Though you can, of course, dedicate 100% of GPU to graphics

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Enabling Compute on PS4™

- Unified memory
- Additional memory buses
  - Take cache coherency into account
- Additional input pipelines
  - Allows rendering and compute loads to be processed in parallel
- Compute shaders
  - Programming model designed for GP GPU
  - Threads not bound to specific input/output data formats
  - Threads can share data and synchronization within a thread group

Additional Memory Buses

- For most tasks CPU and GPU will not need to share memory
  - Each has its own high speed bus and deep caches
- If CPU and GPU need to share memory
  - Maybe doing something with compute
  - buses exist that bypass caches
- Developer should still be cache aware and not tightly couple CPU and GPU work

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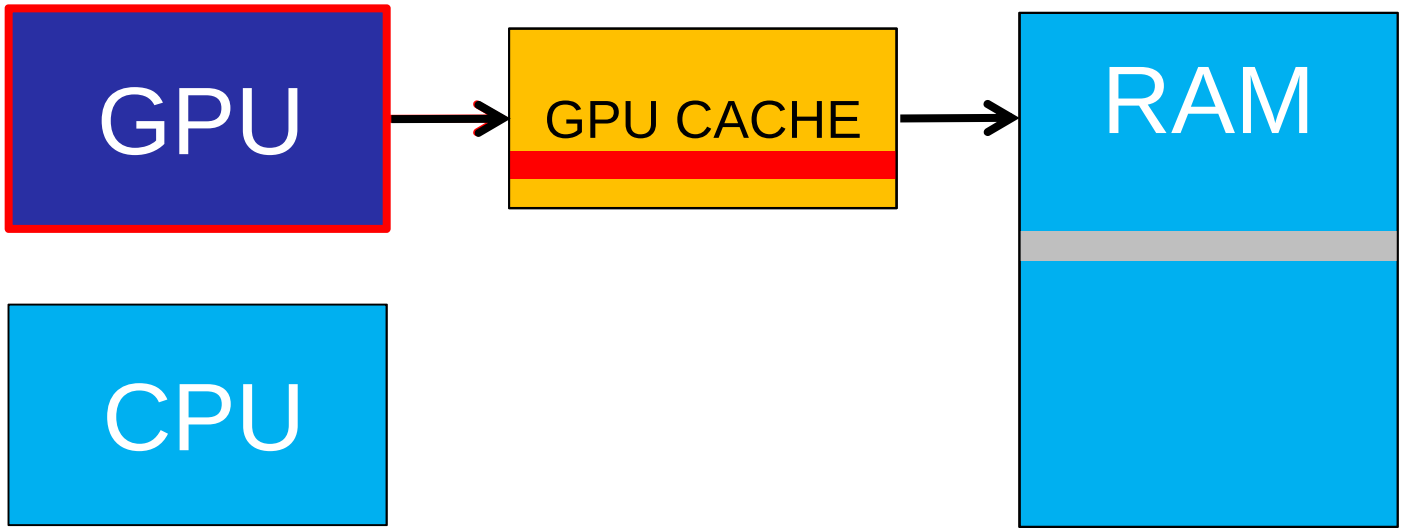
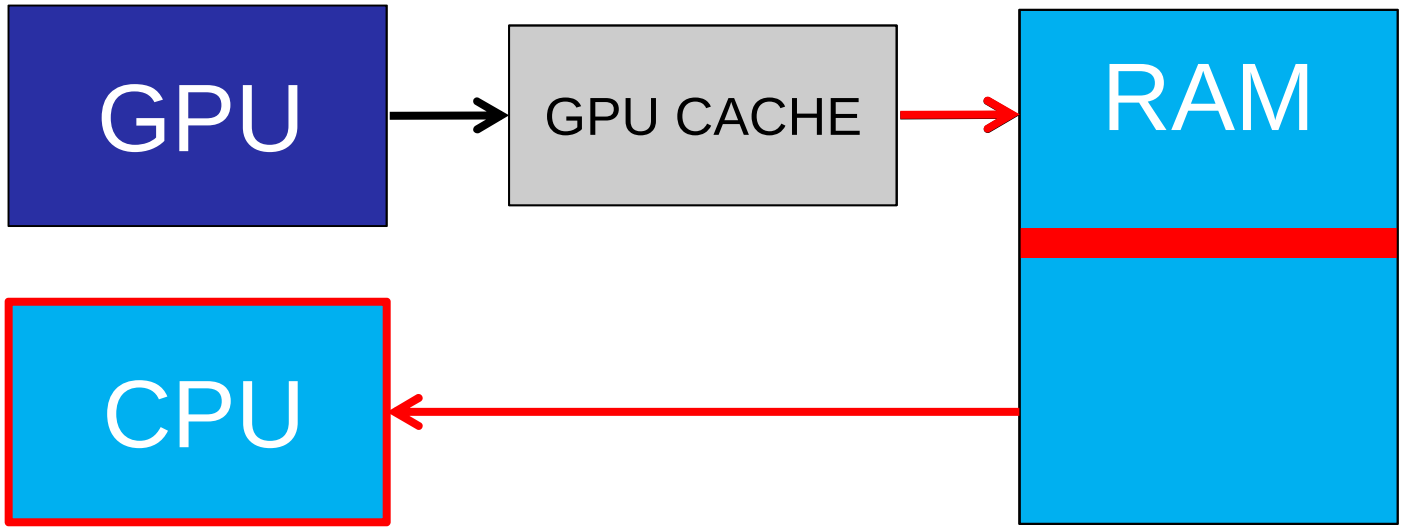
Compute Modifications

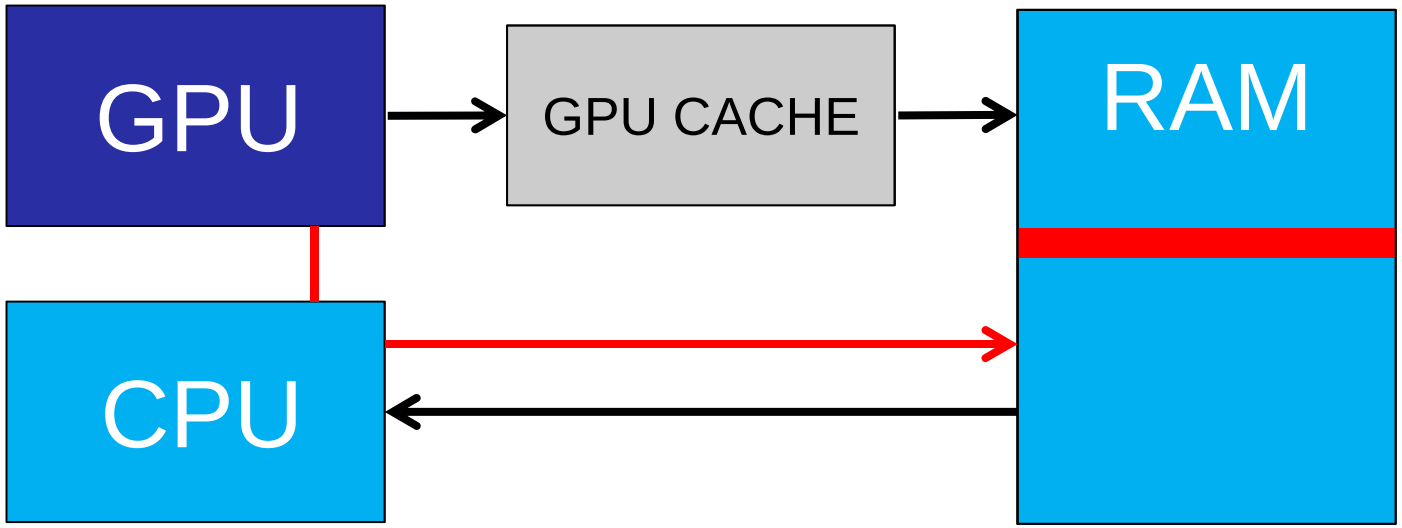


Compute Modifications



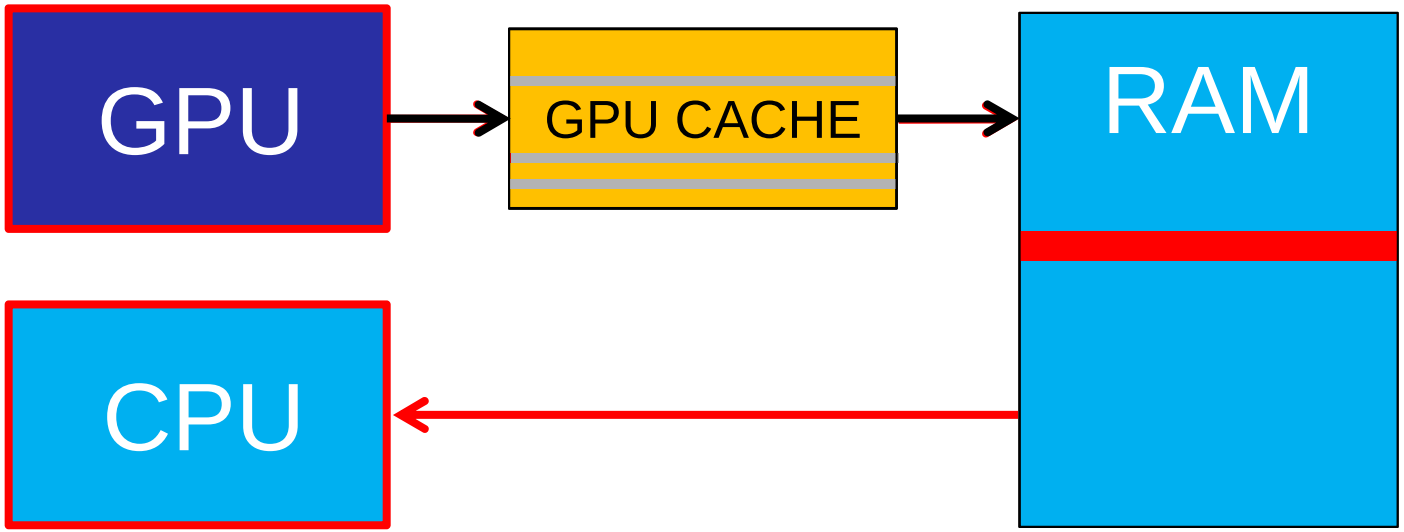
Compute Modifications

- Modification 1: Coherent bus snooping CPU cache



Compute Modifications

- Modification 2: Added a ‘volatile’ bit to cache lines



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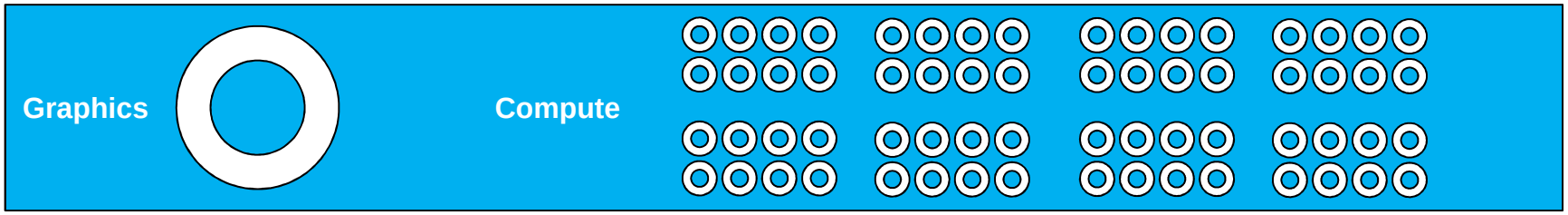
Compute Modifications

- Modification 3: Job Queue in Hardware



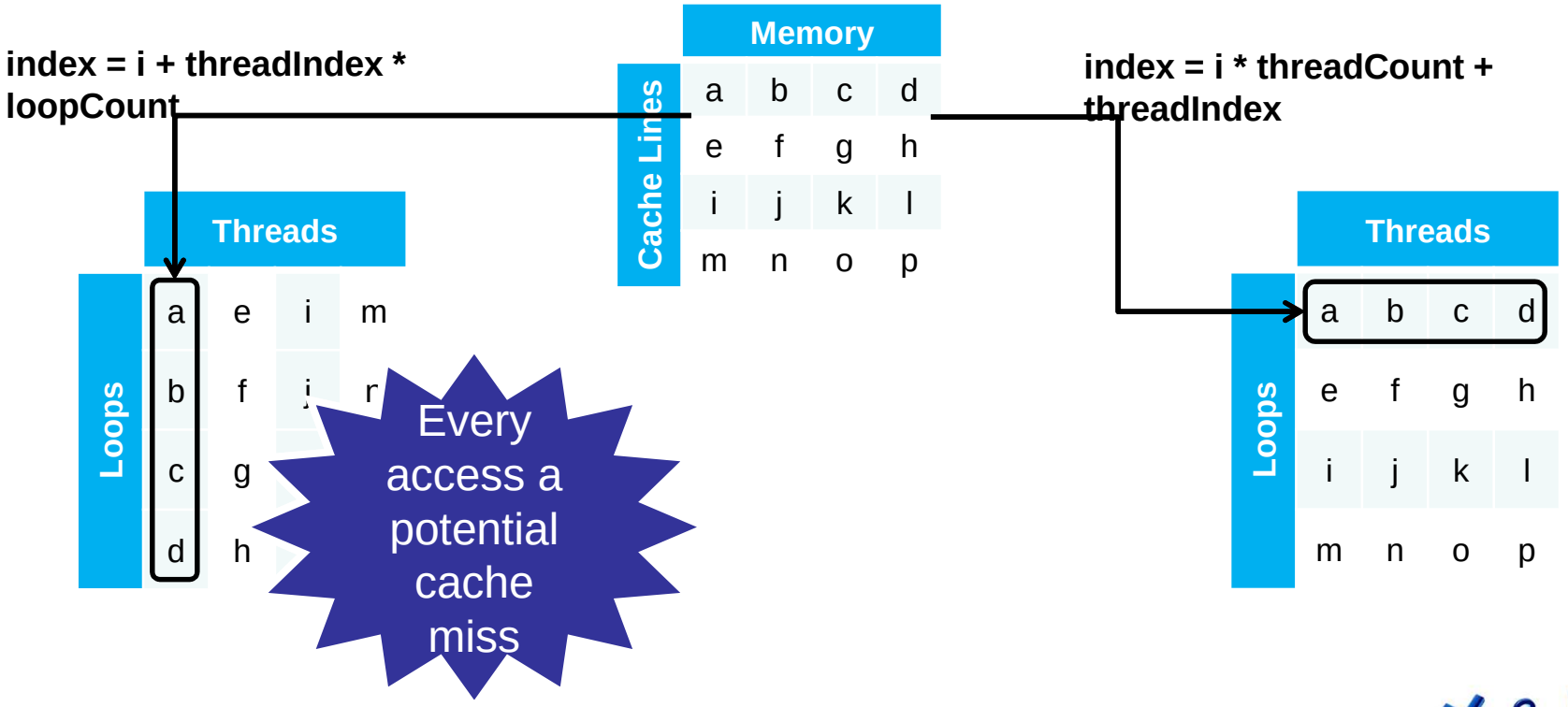
PS4™ Compute

- Why have this fine grain control?

Many Hazards Can Affect Performance

- Kernel Occupancy
- Thread Groups Size vs # of CU
  - More thread groups can reduce latency, but may be less efficient
- Effect of memory buses on GPU
- Divergence within a wavefront
- Wavefront count limitation
- Data Layout
- ….

Data Layout Example



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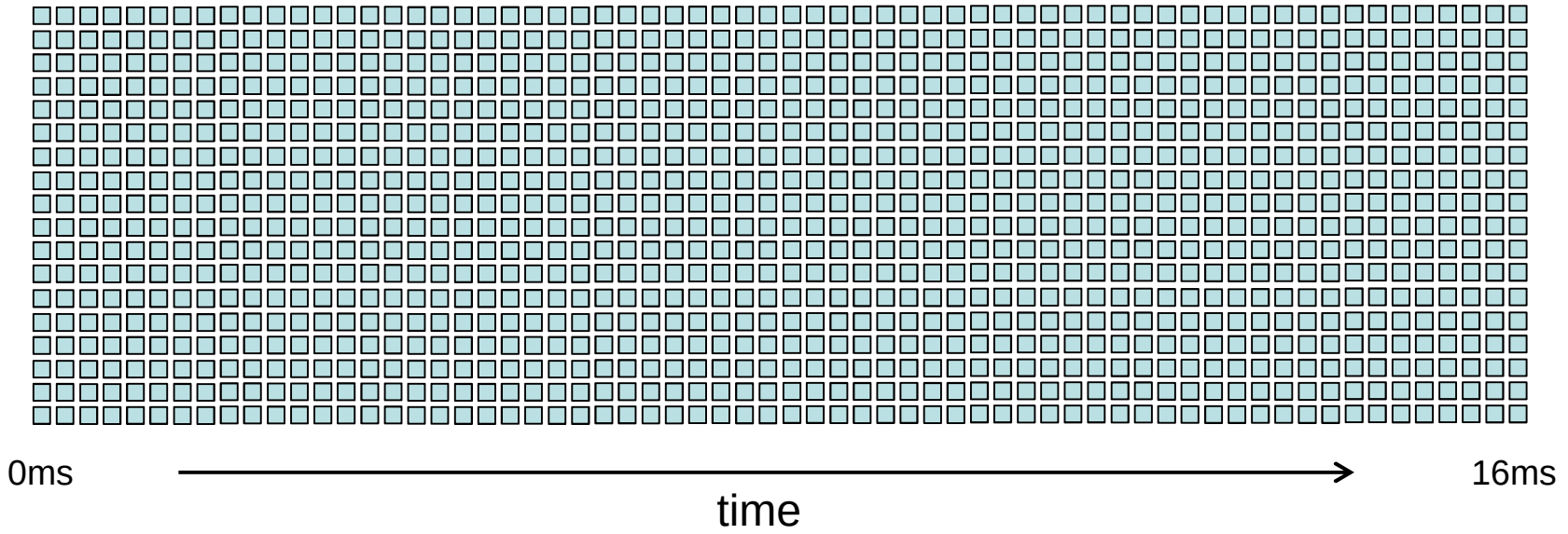
Scheduling Compute



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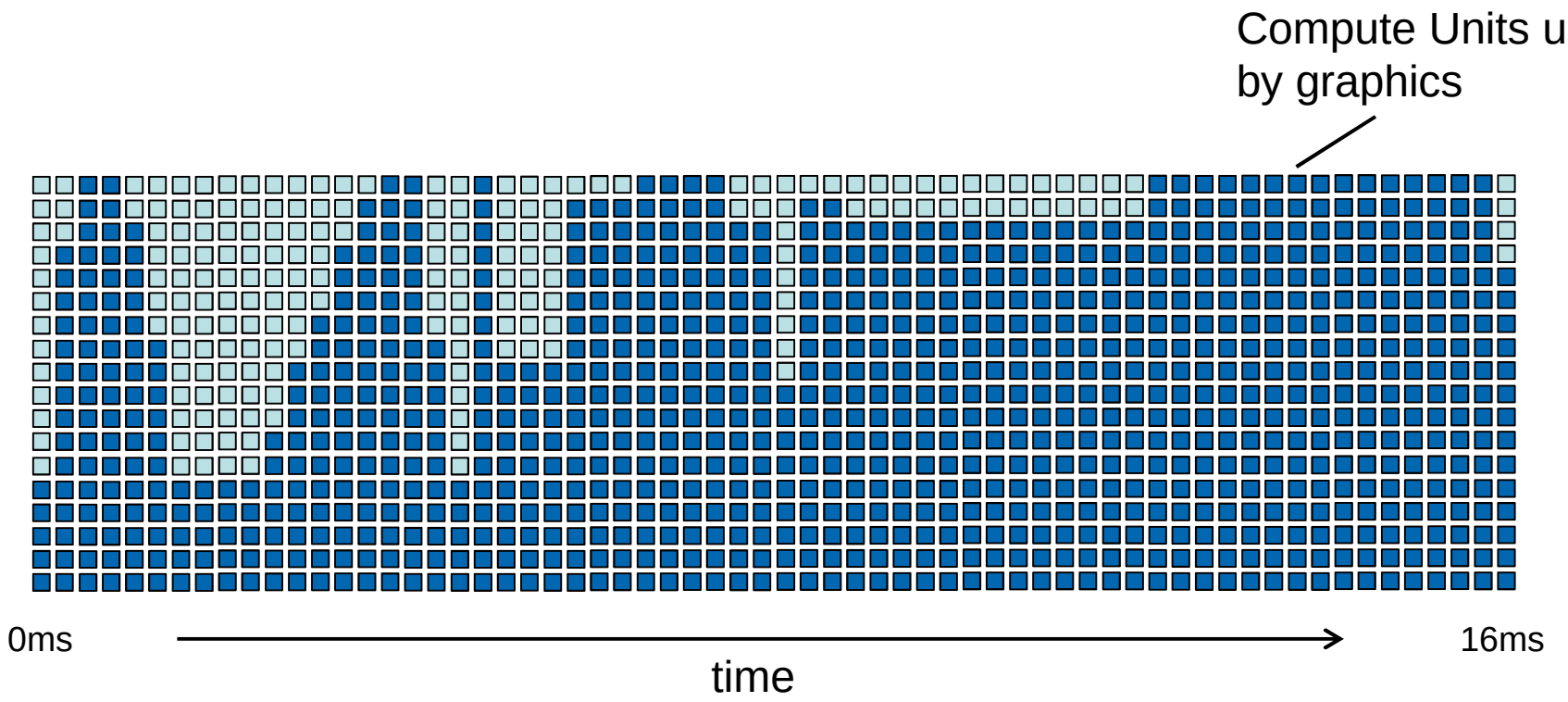
Scheduling Compute



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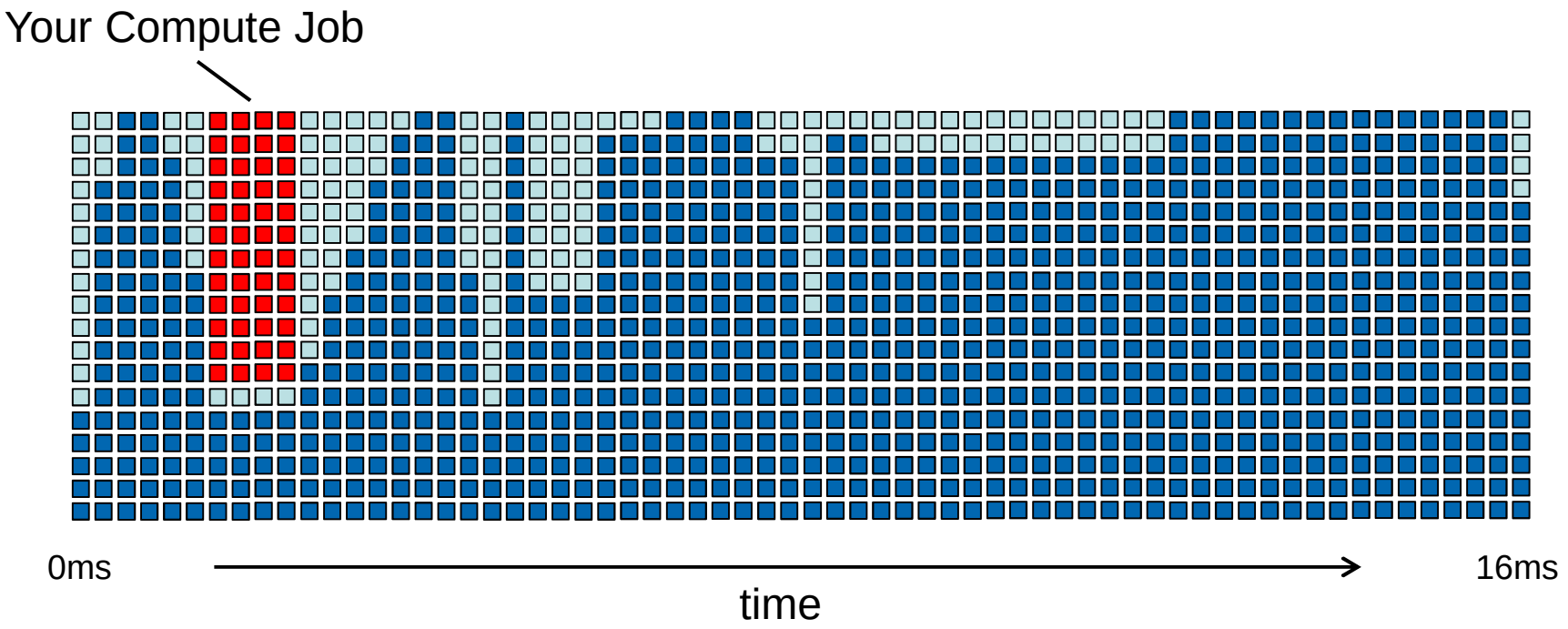

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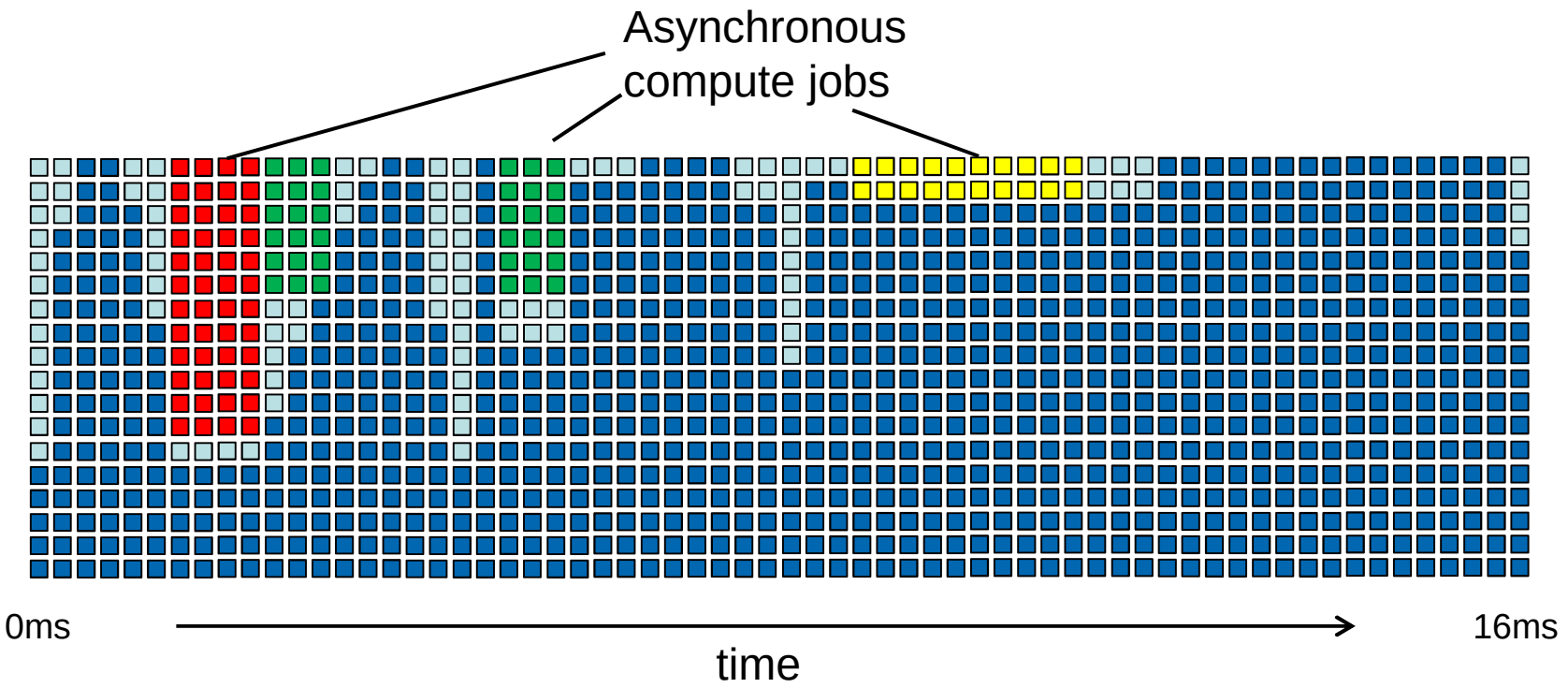

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What We Provide

- Toolchain, SDK, samples
- Developer Services organization
  - Front-line support in multiple time zones
- End-user documentation
  - Compiler Reference; Transition Guide; ABI Overview; Intrinsics Reference
- Testing
  - Conformance, regression, functional

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Development Environment

- Windows
- Tools are fully integrated into Visual Studio®
  - Simple Wizard based project creation
- Compiler, Linker, Debugger
- SN-DBS (distributed build system)
- CPU and GPU performance analyzers
- Similar approaches on PS®Vita and PS4™

Target Management

- Fully integrated into Windows Explorer
- Manage all aspects of devkits
  - Firmware update
  - Launch executable
  - Drag and drop file management
  - Power control and reboot
  - Set devkit parameters
  - Monitor TTY output
- Capture and playback controller input
- Also includes command line tools and API for custom tools
  - Supports C++, managed C++, C#, VB

Debugger

- Debug your code as you would your PC code
- Mirrors the Visual Studio® multi-threaded debugging feature set
- Advanced feature support
  - Core dump debugging
  - Parallel call stacks and watches
  - Thread-specific break points and trace points

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SN-DBS

- Fault tolerant distributed builds of code and data
  - Supports custom data tools for building shaders, lighting calculations, texture conversions, game scripts, etc.
- Supports native code tools on all versions of Windows
- Immediate benefit from small numbers of machines
  - Scales to hundreds of machines easily
- **Included for free**

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Performance Analysis

- CPU Performance
  - Captures CPU data while you play the game
  - Captured data can be analyzed, saved, and exported
  - Helps you eliminate conflicts and bottlenecks
- GPU Performance
  - Capture graphics data for playback and analysis later
  - Easy to monitor textures, buffers, shaders, and find performance hot spots
  - Thread Trace Visualizer

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- Free game engine
- Out of the box on
  - PS4™, PS3™, PS®Vita
  - Windows (GL & DX11)
- All in one package
  - Optimised for PlayStation® platforms
  - Same interface on all platforms – easy to target all simultaneously

- Recent Titles
  - Journey
  - Hotline Miami
  - Knytt Underground
  - RocketBirds: Hardboiled Chicken
- And 130+ more titles
  - And across a wide range of formats
- Several PS4™ launch titles such as Super Motherload

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Tools and Middleware Support

- Engine
  - Bitsquid
  - CryEngine 3
  - Silicon Studio PARADOX
  - Terathon C4 Engine
  - Unity
  - Unreal Engine 4
- Audio
  - Audiokinetic Wwise
  - CRI ADX2
  - Firelight Technologies FMOD
  - RAD Game Tools
- Art/Graphics/Animation
  - Allegorithmic
  - AristenFX
  - Autodesk
  - Confetti Interactive
  - Cybernoids
  - FaceFX
  - Fork Particle
  - Geomerics
  - IKinema
  - Matchlock BISHAMON
  - PopcornFX
  - SpeedTree
  - Umbra
- Physics/Simulation/AI
  - BabelFlux NavPower
  - Havok
  - NaturalMotion
  - Nvidia
  - Simul Software trueSKY
  - xaitment xaitControl
- Others
  - Deja Tools
  - Incredibuild
  - RakNet

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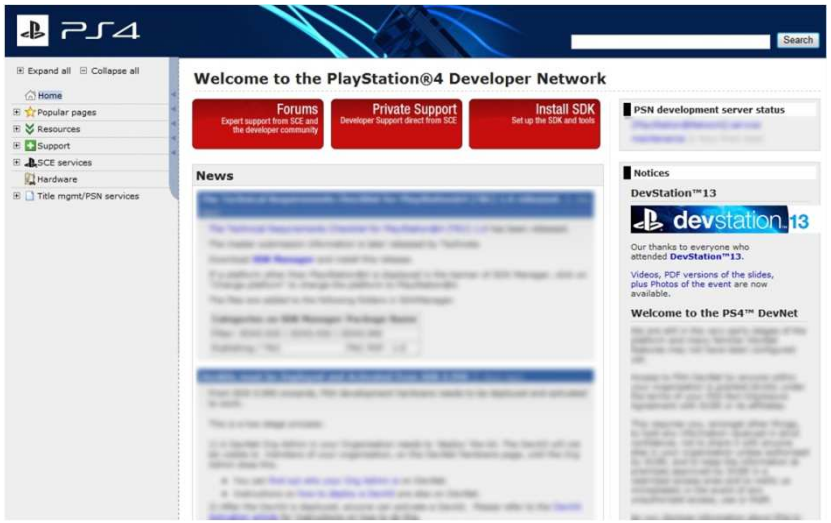
Developer Services

- PlayStation® DevNet
  - SDK, tools and training videos
  - Access Retail Crash Dumps
  - Forums, private support
- Private Support
  - Free to all: AAA to Indie dev
  - Performance Analysis
- DevStation
  - European-wide developer event
  - Global R&D



devstation™

PS4

Summary

- Why develop on PlayStation®?
  - Powerful, low-level access to hardware
  - Simple APIs
  - Wide array of tools and support for middleware
  - Next-gen network services
  - Personal support


Devs


PS4™


Q & A