XBOX ONE

Main SoC and XBOX One Kinect

John Sell

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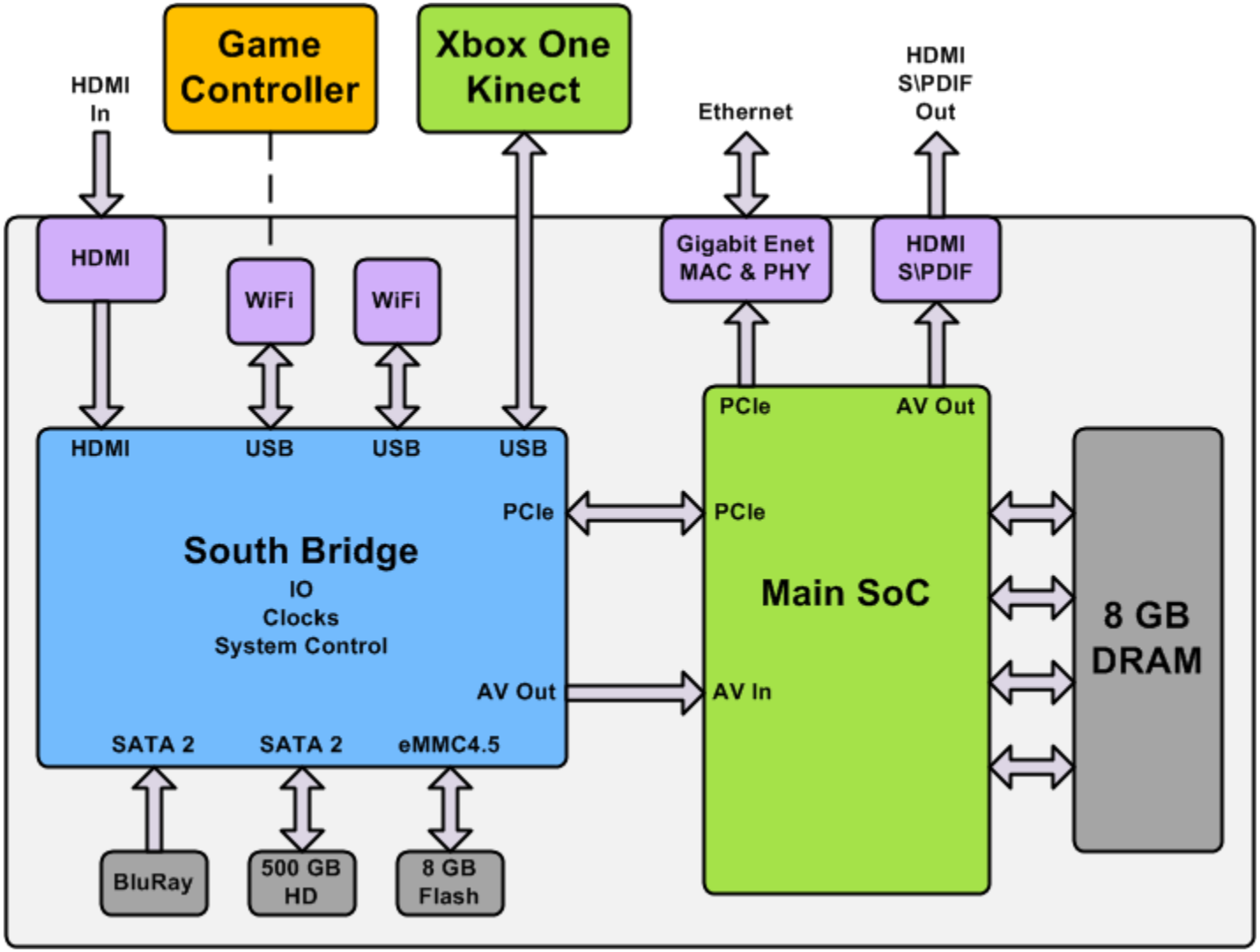
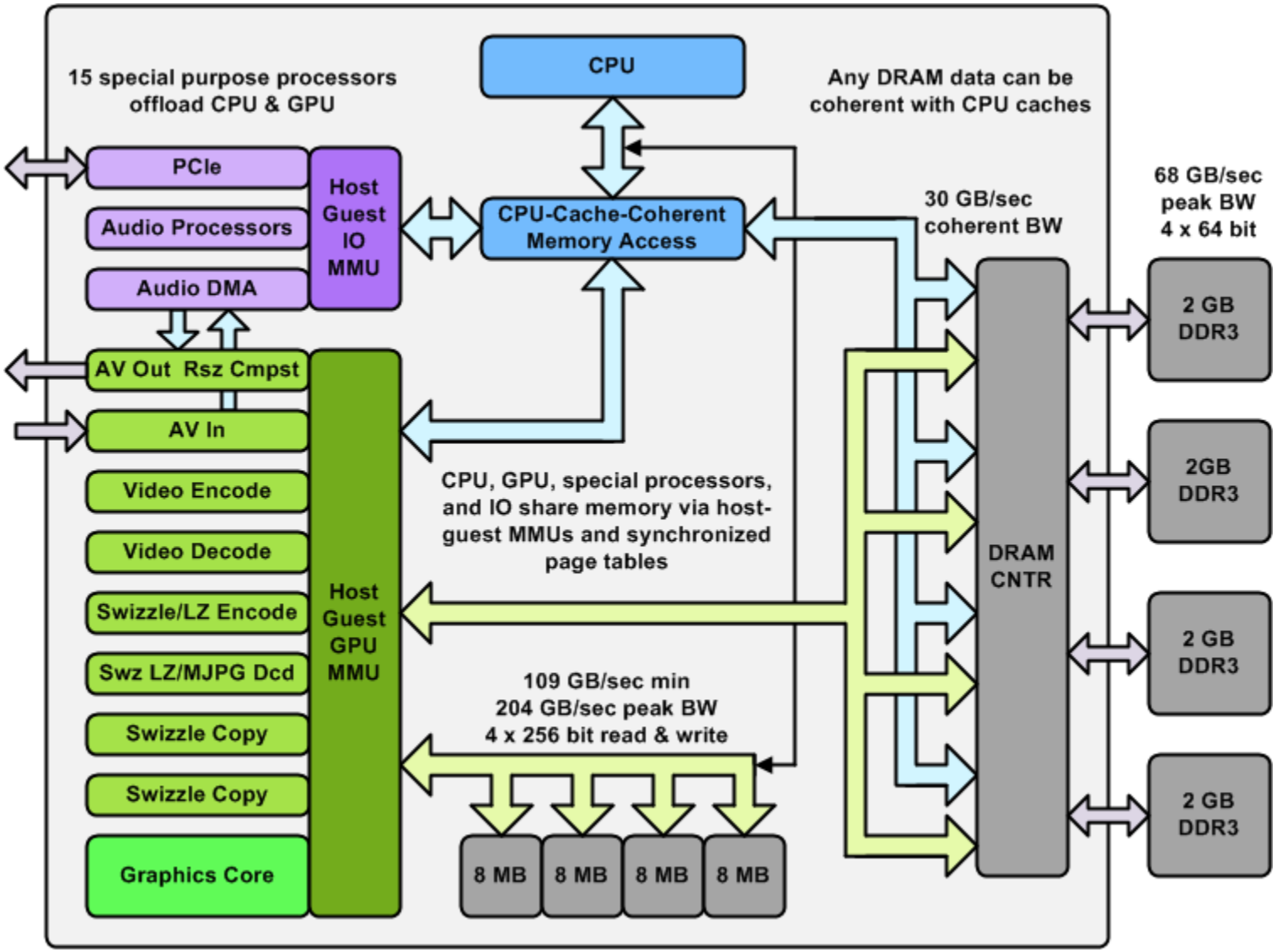
Xbox One


Game Controller
Xbox One Kinect
HDMI In
Ethernet
HDMI S\PDIF Out
HDMI
WiFi
WiFi
Gigabit Enet MAC & PHY
HDMI S\PDIF
PCIe
AV Out
HDMI
USB
USB
USB
PCIe
PCIe
South Bridge
IO
Clocks
System Control
Main SoC
8 GB DRAM
AV Out
AV In
SATA 2
SATA 2
eMMC4.5
BluRay
500 GB HD
8 GB Flash

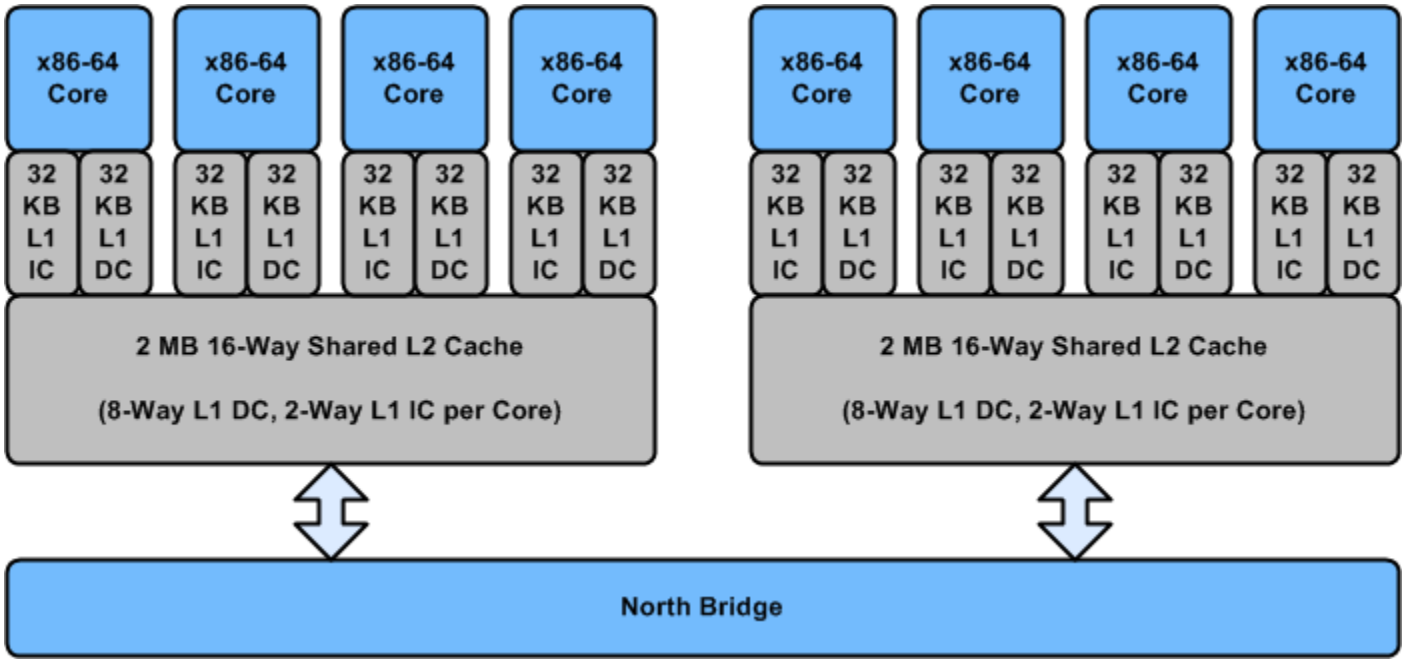
Main SoC

- 363 mm2
- 28 nm TSMC HP
- 5 billion transistors
- 47 Mbytes of storage on chip
- Power islands and clock gating to 2.5% of full power

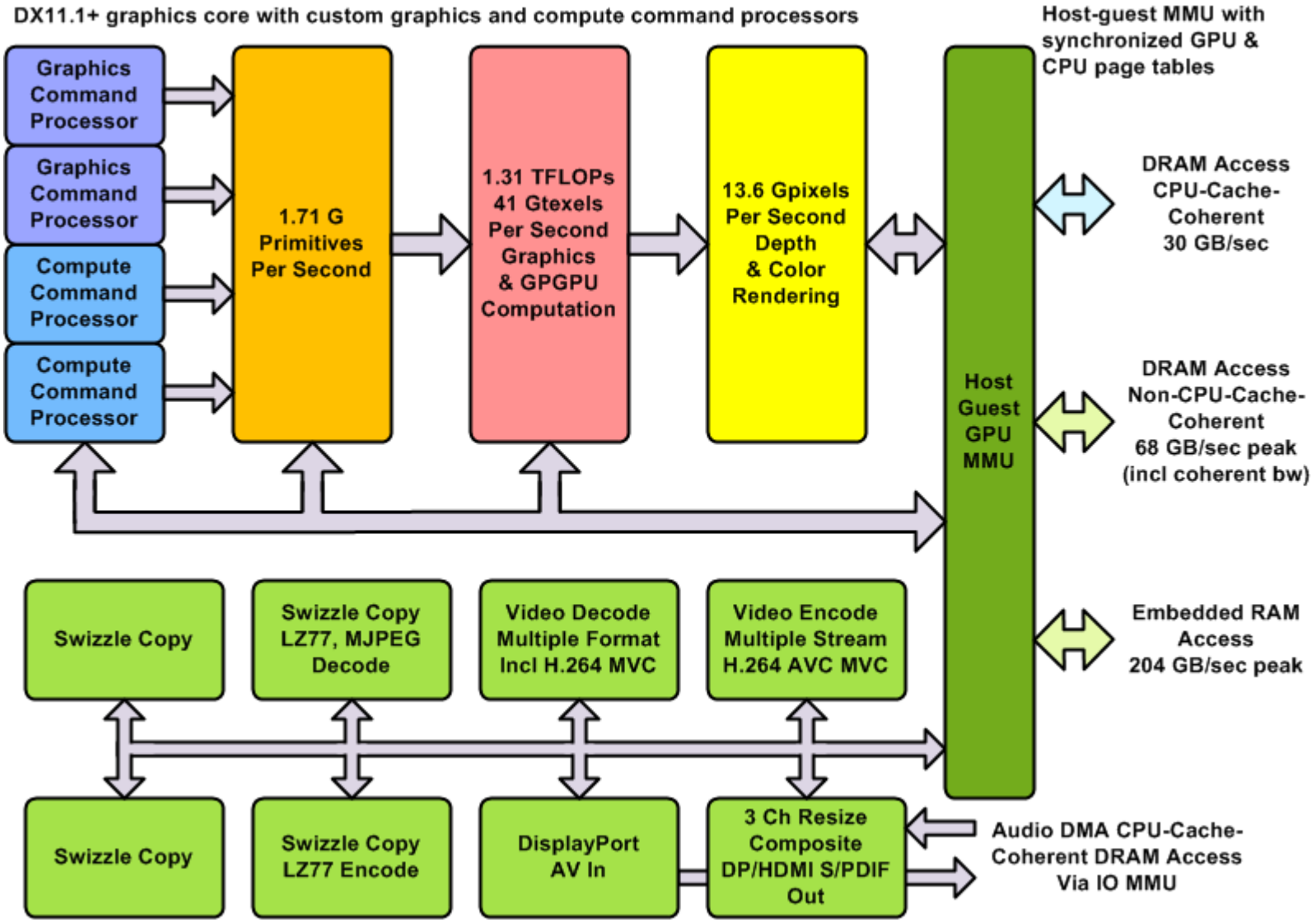
SoC Components



CPU

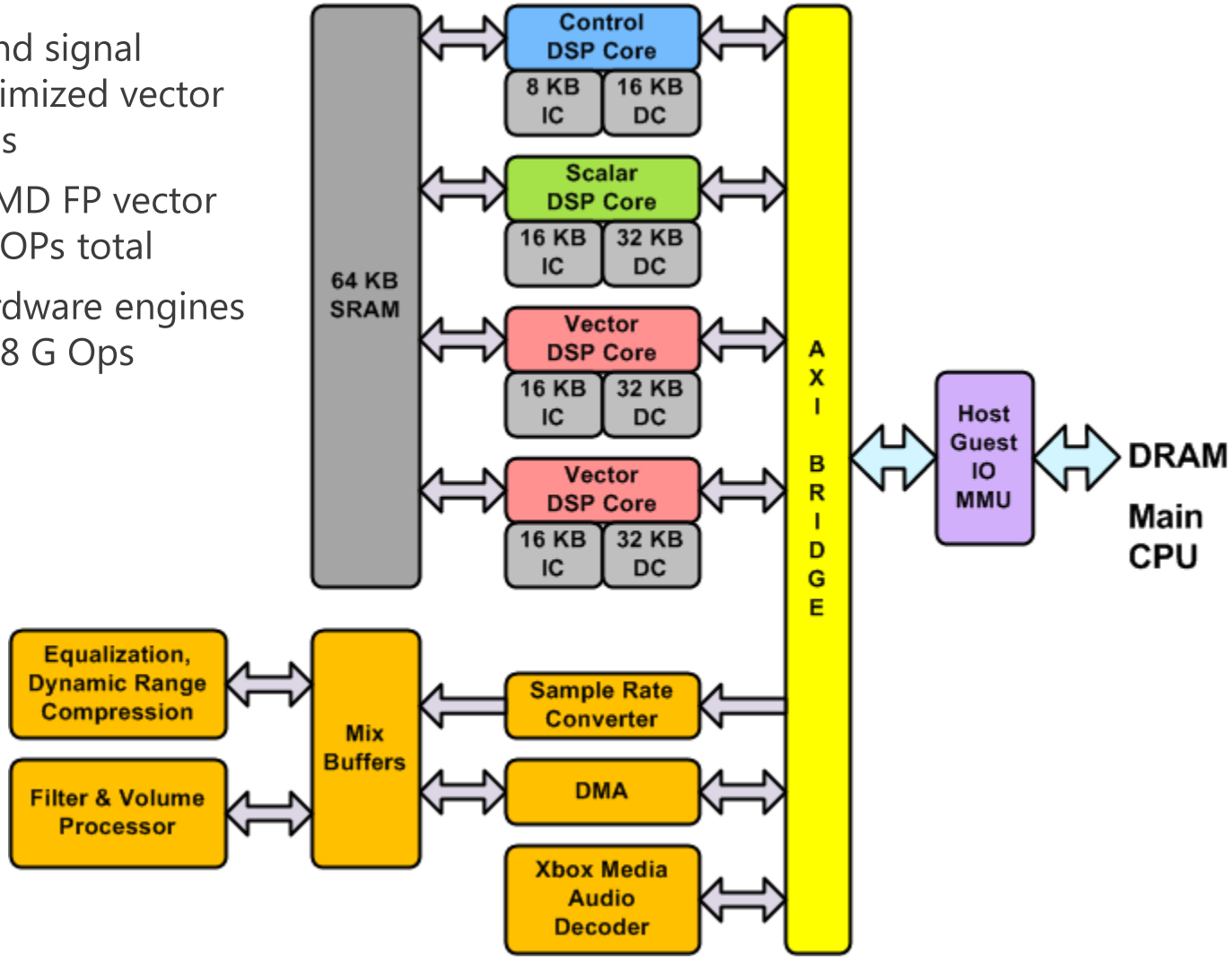

x86-64 Core
x86-64 Core
x86-64 Core
x86-64 Core
x86-64 Core
x86-64 Core
x86-64 Core
x86-64 Core
32 KB L1 IC
32 KB L1 DC
2 MB 16-Way Shared L2 Cache
(8-Way L1 DC, 2-Way L1 IC per Core)
2 MB 16-Way Shared L2 Cache
(8-Way L1 DC, 2-Way L1 IC per Core)
North Bridge

GPU and GPU MMU Clients



Audio Processors

- Audio codec and signal processing optimized vector and scalar cores
- Two 128-bit SIMD FP vector cores, 15.4 GFLOPs total
- Specialized hardware engines equivalent to 18 G Ops



SoC Summary

- High performance, but power efficient, and very low power modes
- AV in and out media hub
- Specialized audio, graphics, and video processors offload CPU and graphics core
- CPU, GPU, specialized processors, and IO share memory via host-guest MMUs with synchronized page tables
- High bandwidth CPU cache coherency
- 200+ GB/second power efficient memory system balanced to CPU, GPU, specialized processors, and IO requirements
- DX11.1+ graphics core with custom graphics and compute command processors to offload CPU and improve GPGPU

Different Needs – Different Solution

Xbox One Kinect

XBOX

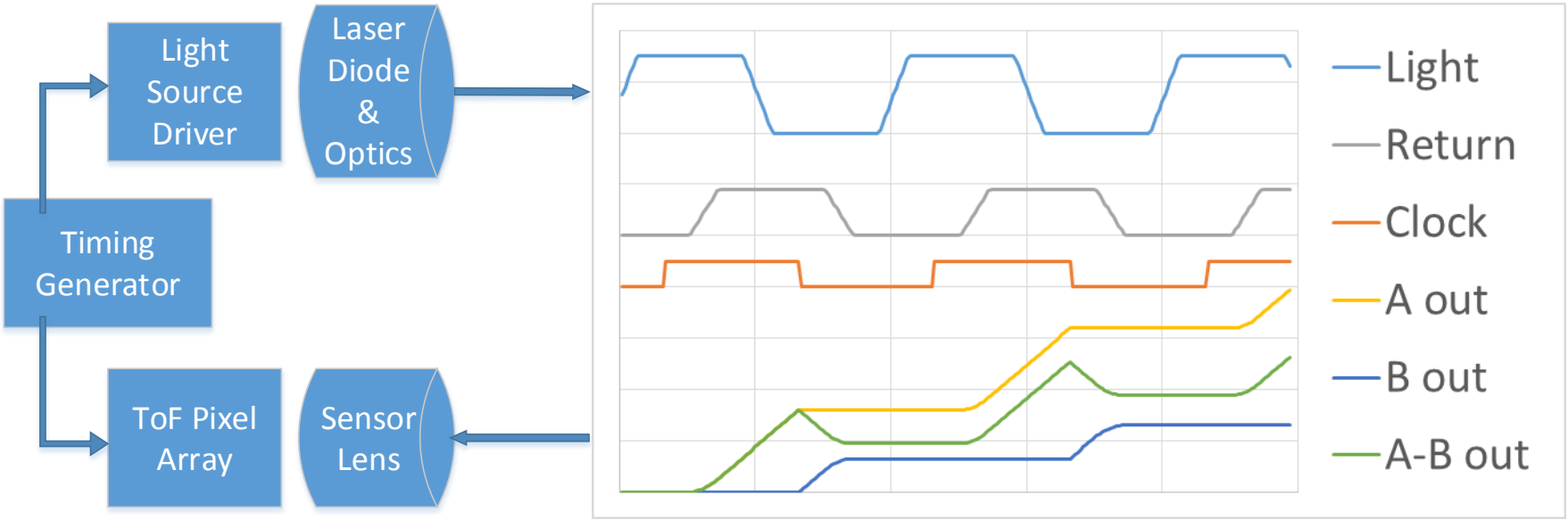
A Next Generation Kinect Experience

User Experience	Technical Requirement
Consistent performance, kids & adults – child's wrist	Depth resolution of ~1% Minimum SW-detectable object <2.5cm
Playspace Flexibility Small or Large rooms, Multiple players	Full spec operation 0.8m – 4.2m range 70° Horizontal optical field of view
Accurate, Responsive, Consistent User Experience	<2% accuracy, <20ms latency to SW, <14ms total exposure time
Lighting Independent	Depth performance independent of room lighting

→***Microsoft designed a new highly-customized image sensor based on Time of Flight Technology to meet this need***

A Differential Pixel

For an XBOX One Kinect Depth Sensor



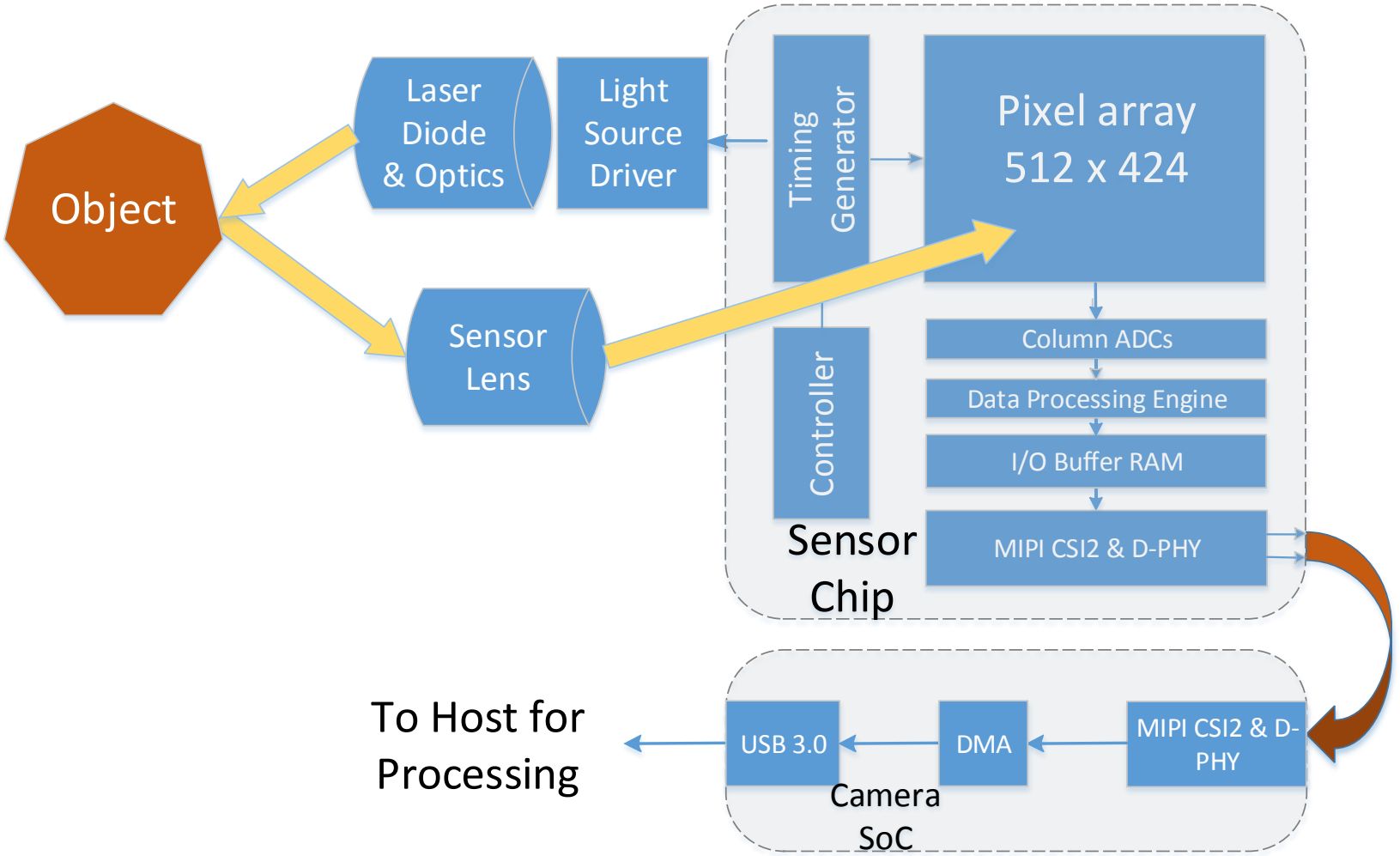
Differential Pixel

- (A+B) gives the ambient (room) lighting ('common mode') – 'normal' grey scale image
- (A-B) gives phase (depth) information after an arctan calculation – depth image
- $\sqrt{\Sigma(A-B)^2}$ is the 'Active' image – A grey scale image independent of ambient lighting

→***Depth & Image performance is per-pixel, defined by optical & electrical parameters***

Sensor System Block Diagram

Time Of Flight Technology can deliver the performance needed



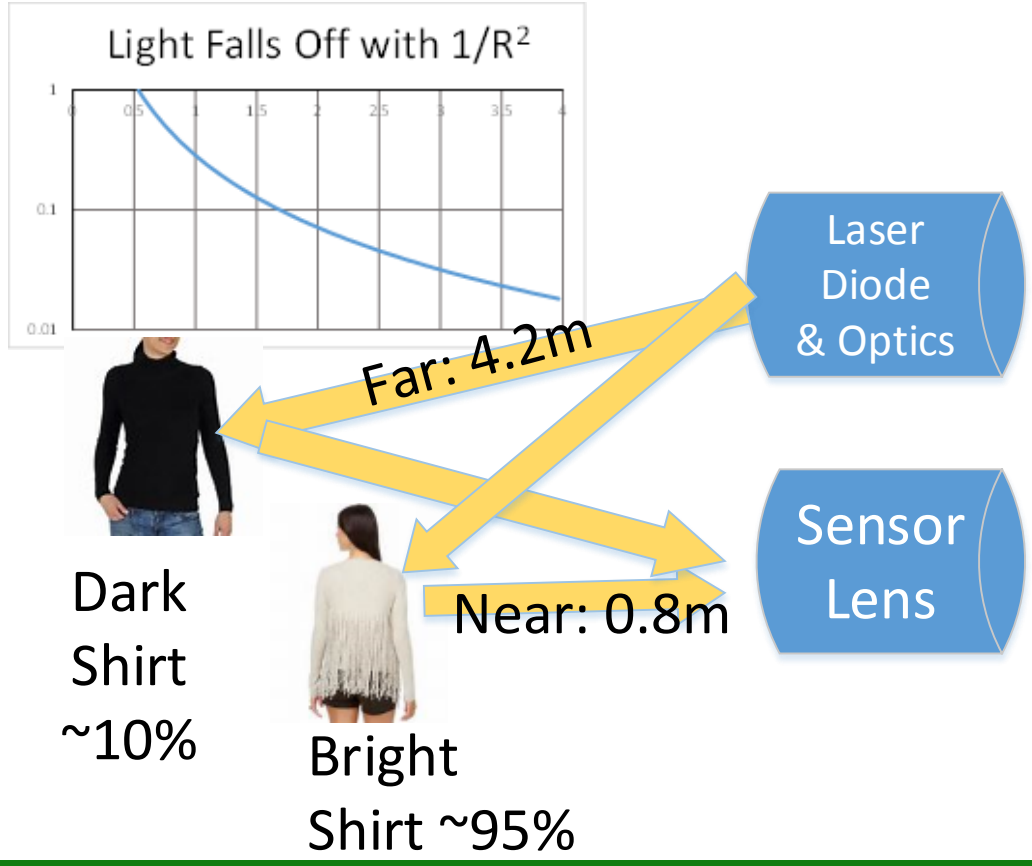
Near & Far, Reflective & Non-Reflective

High dynamic range is required to enable robust multi-player capability

- Performance ~ SNR → Multiple players
  - *Must meet minimum SNR at all points in the room simultaneously*

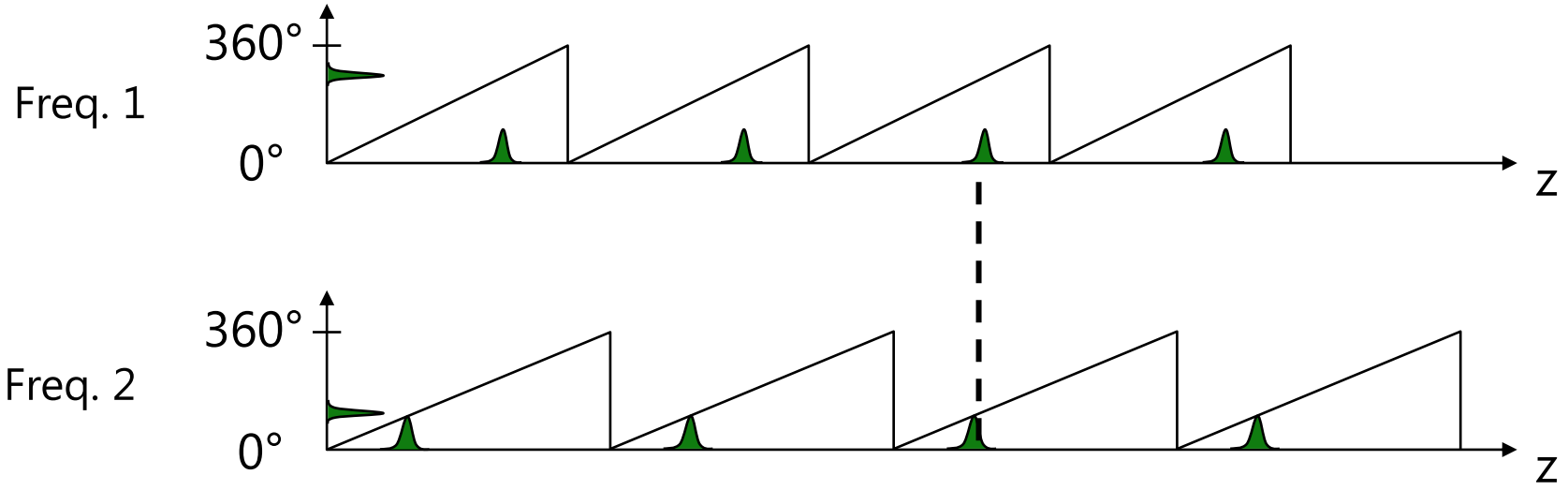
- Cannot use normal photographic tricks of Aperture / Exposure
- Need a dynamic range of ~2500x

  - *Use 2 or more shutter times, choose which gives the best image*



Need High Z-resolution over long range

Phase ‘wraps’ at 360º – 3.75m for 80MHz – Must we use a lower frequency?



- Each frequency gives a wrapped estimate of distance
- With the combination, find the unwrapped distance
- Allows high frequency (good for resolution) over long distance

Room Light Conditions Distorts 2D Images

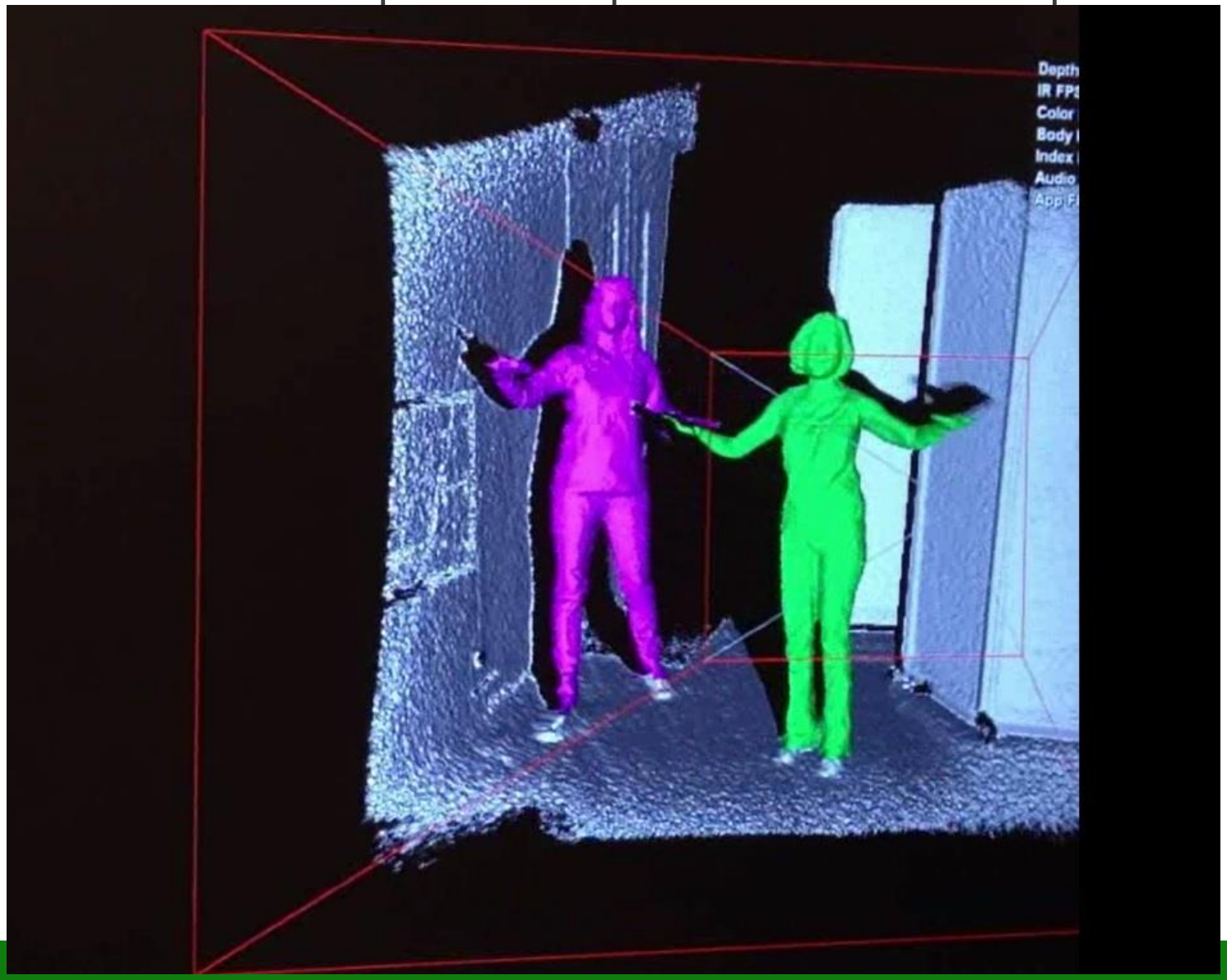
Active IR Provides Consistently Lit Images

- Example: A side-lit face has shadowing that confuses SW
- *The Active image is front-lit and insensitive to room lighting*

A Regular Color Camera

Active, same conditions

Real Time Depth Captured @30fps



Thank You!

Microsoft Silicon Development Team

XBOX