PCI Express – A High-bandwidth Interface for Multi-camera Embedded Systems

ximea

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Overview

- XIMEA quick intro
- Camera manufacturers eco space
- Challenges and requirements to integrate an imager (camera or sensor) into embedded imaging system
- Existing imager interfaces, pros/cons
- PCIe does it all
- Proof “PCIe does it all”: HW scalability and SW transparency
- Invite to visit Summit Technology Showcase with live demo

XIMEA quick intro

XIMEA quick intro

- Versatile camera manufacturer for more than 25 years
- Recognized as an innovator in Machine vision and Imaging markets
- Located in Germany, Slovakia and USA
- 50% standard and 50% custom/OEM products:
  - Sensor resolutions from VGA to 50 Mpix
  - Frame rates up to 3500 fps
  - API/SDK support for variety of operating systems and hosts
  - Multiple interfaces, short/medium/long distances
  - Extremely compact camera arrangements
  - Aggregation of data from multiple imagers into a single cable

Camera Manufacturer Ecospace

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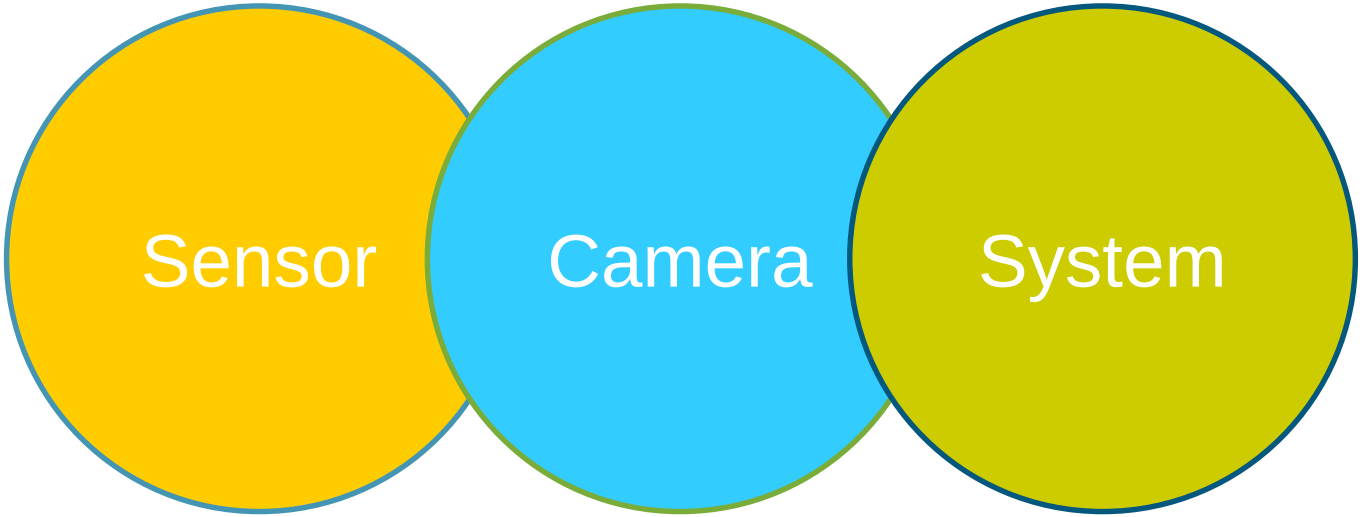
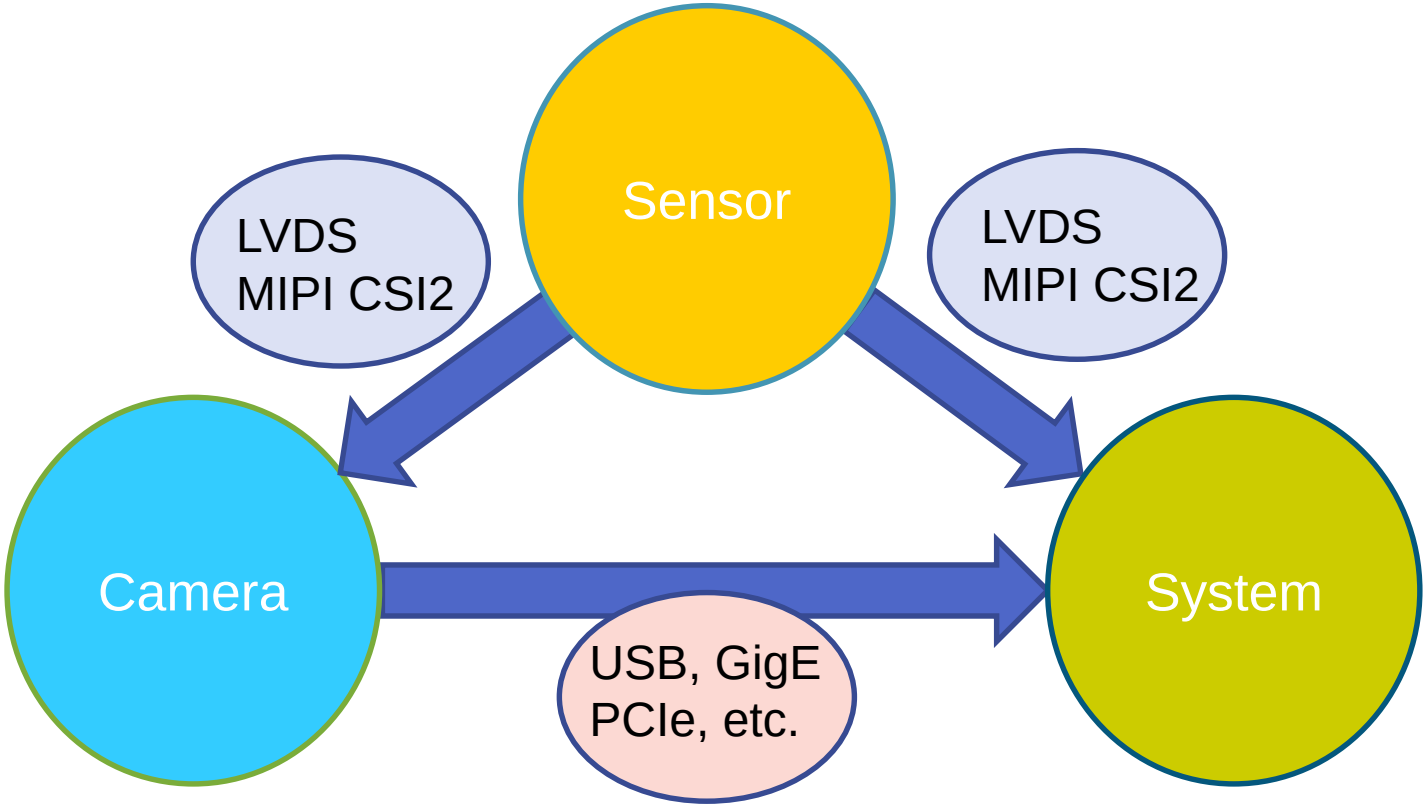


Camera Manufacturer Ecospace



Camera Manufacturer's Ultimate Goal

- acquire perfect images and seamlessly deliver it to the processor
- … respecting all prerequisites of a system
- … removing hassles and efforts of integrating a "bare sensor"
- … providing middleware in regards to HW and SW
- … extensive support

Challenges and requirements to integrate an imager into embedded imaging system

- Minimize Latency, Power and CPU overhead
- High bandwidth demands, multiple formats, multiple imagers, and growing …
- Synchronization between imagers, time stamping, metadata
- Minimize effort to integrate a (different) imager or processor, both HW and SW
- Modify or reuse existing setups for new applications

Existing Imager Interfaces

Existing Camera and Sensor Interfaces

	LVDS subLVDS	MIPI CSI-2 C-PHY	USB/GigE	PCIe
Range	mm to cm	mm to m	cm to hm	mm to hm
BW per lane, Gb/s	0.3 … 3	2.5	0.5 … 10	2.5 … 8
Number of lanes	1 … 64	1 … 4	1	1 … 16
Aggregated BW, Gb/s	0.3 … 200	2.5 … 10	0.5 … 10	2.5 … 128

LVDS/subLVDS

- Provided either directly from the sensor or from FPGA in the camera
- Usually not supported by hosts and SoC, thus requires FPGA glue logic on the host side
- Moves complexity from the camera to the host
- Variety of specifications, no standard
- Today’s sensors and FPGAs do not support bandwidth above 1.6 Gb/s
- Low cost

MIPI CSI-2, C-PHY

- Provided directly from the sensor
- Usually supported by SoC
- Deal with sensor settings on a register level
- Lowest cost

USB and GigE

- Versatile camera interface
- Convenient from the host perspective
- Industrial standards **USB3 Vision** and **GigE Vision**
- Several software API/SDKs exist to integrate cameras
- Requires massive SW stacks on the host side
- High latency and CPU overheads
- Power hungry
- Highest cost

PCIe does it all

- Minimizes latency and CPU overhead
- Seamlessly delivers image data directly to the host memory via Scatter/Gather DMA
- Supports distances from millimeters to hundreds of meters
- Aggregation of multiple imagers into one wire/fiber
- Thin to none SW stack

- Ultimate Camera Interface for Embedded Vision Systems

Pros and Cons

	LVDS subLVDS	MIPI CSI-2 C-PHY	USB/GigE	PCIe
Standard	No	Yes	Yes	Yes
Imager HW overhead	Low	Low	High	Medium
Imager SW overhead	Medium	Low	High	Low
Processor HW overhead	High	Medium	High	Low
Processor SW overhead	Medium	Medium	High	Low
Multiple imagers	No	No	Yes	Yes
Latency	Low	Low	High	Low
Power	Low	Low	Medium	Medium

xPlatform – XIMEA PCIe camera platform

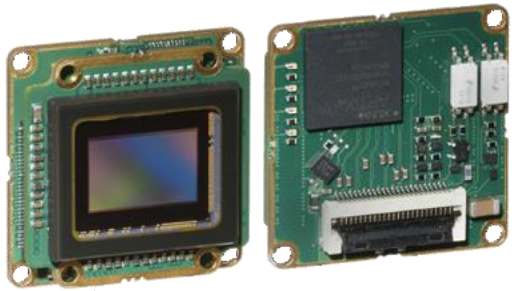
xPlatform – XIMEA PCIe camera platform

xiX – XIMEA PCIe camera family

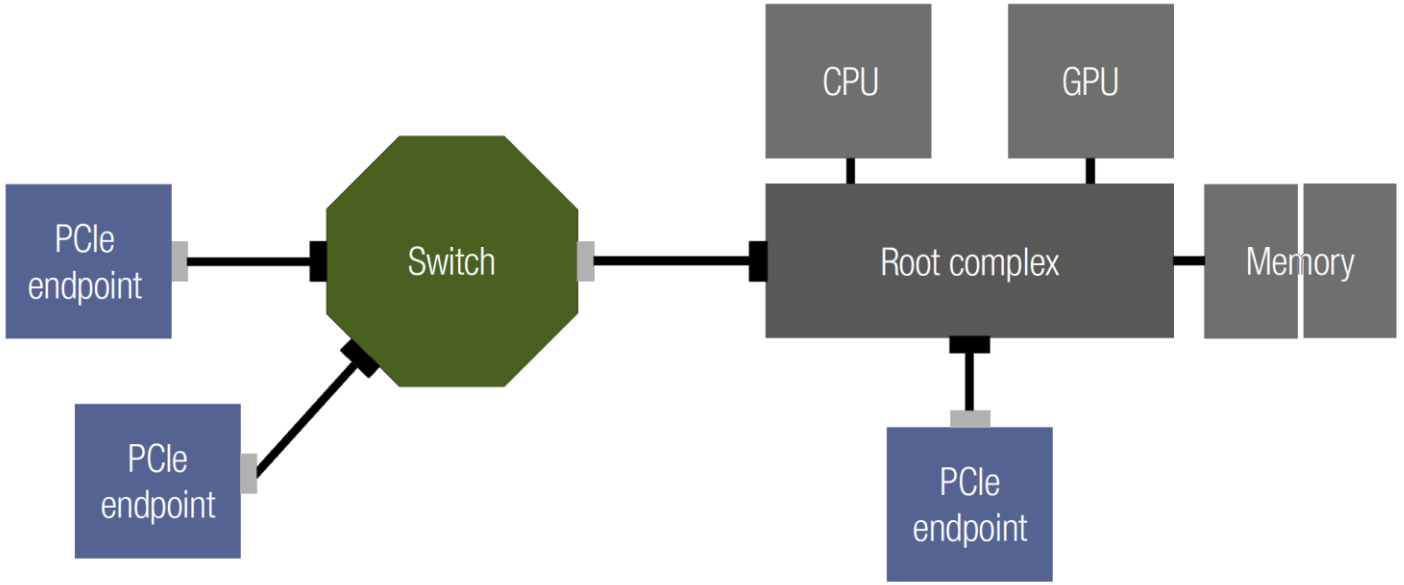
- Resolutions
  VGA … 50 Mpix
- Framerate
  up to 3500 fps @1 Mpix
- PCIe interface
  X1Gen2 … X8Gen3
  5 Gb/s … 64 Gb/s

xiX – XIMEA PCIe camera family

- Variety of form factors housed and board level
- Compact size and low power

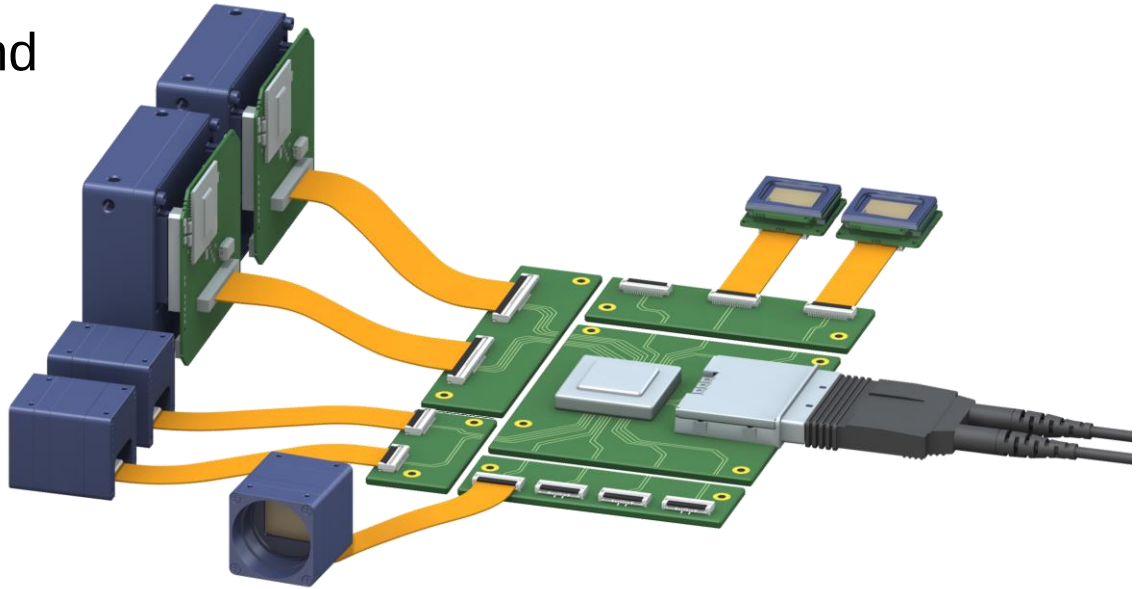


Topology of PCIe embedded system

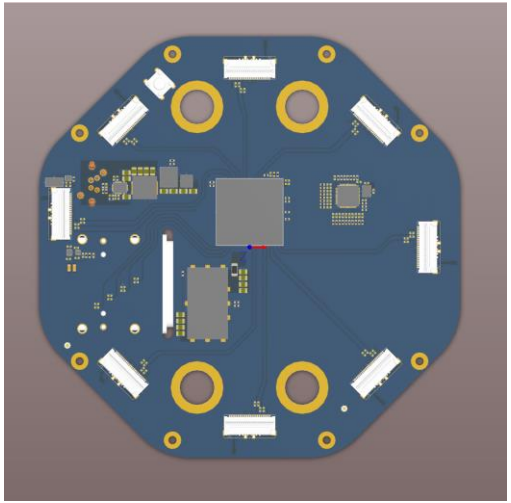


xiSwitch – PCIe Multi-camera aggregation

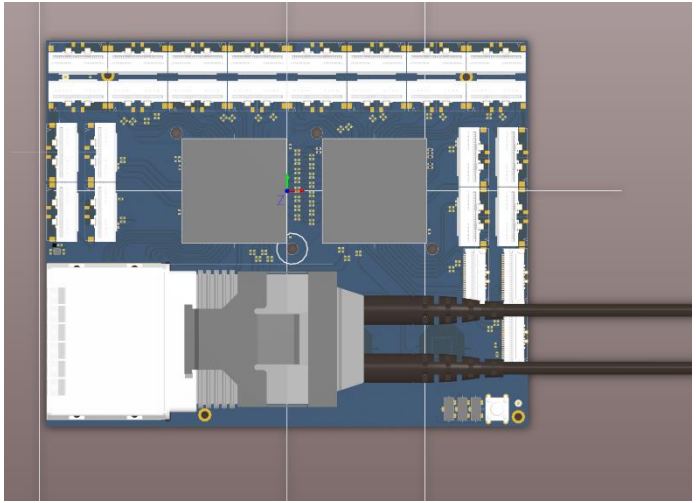
- Several cameras aggregated into one high bandwidth upstream up to 64 Gbit/s
- Maximum compactness and modularity



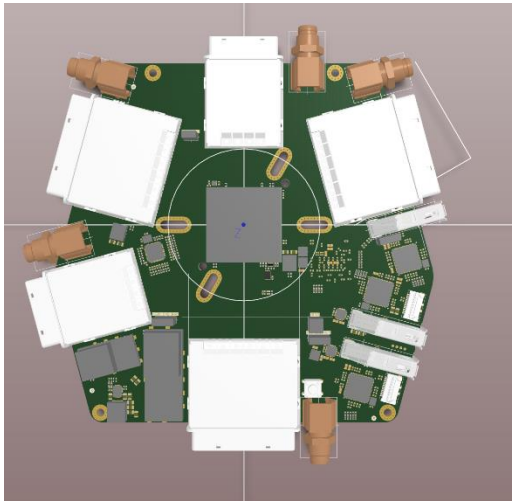
xiSwitch – examples



Downstream 8x 10 Gb/s
Upstream 1x 32 Gb/s



Downstream 27x 10 Gb/s
Upstream 1x 64 Gb/s



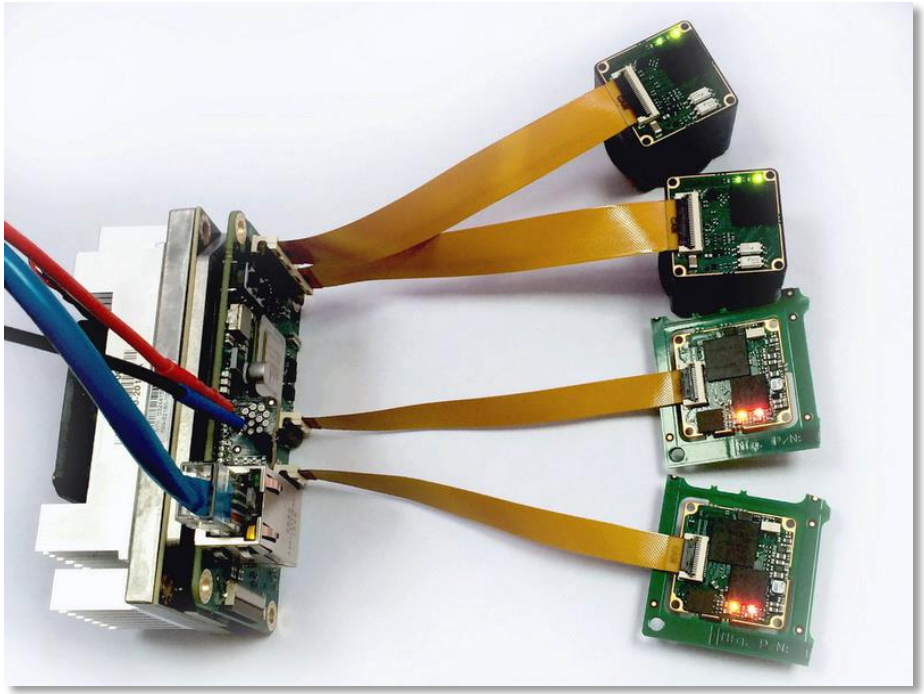
Downstream 2x 64 Gb/s
2x 32 Gb/s, 5x USB 3.0
Upstream 1x 64 Gb/s

xPlatform – example 360° rig

- 8x FullHD cameras IMX174 each streaming at 165 fps
- All aggregated into one x4G3 32 Gb/s fiber cable
- Up to 100 m cable length

xPlatform – embedded example NVIDIA TX1/TX2

- 2x FullHD cameras IMX174
- 2x 9 Mpix cameras IMX255
- All streaming directly to TX1/TX2 memory



Welcome to Summit Technology Showcase to see Live demo

xPlatform Resources

- xiX infographics
  https://www.ximea.com/files/brochures/xiX%20Infographic.pdf
- xiX brochure
  https://www.ximea.com/files/brochures/xiX-OEM-cameras-for-integration-2017-brochure-HQ.pdf
- xiSwitch infographics
  https://www.ximea.com/files/brochures/xiSWITCH%20Infographic.pdf
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Q&A

- Thank you for your attention

Questions?