



Tom Watzka & Satwant Singh
Lattice Semiconductor

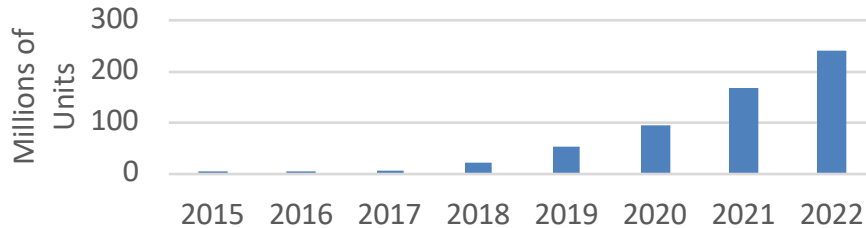
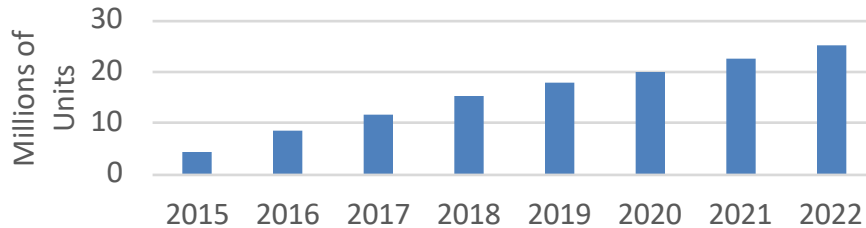
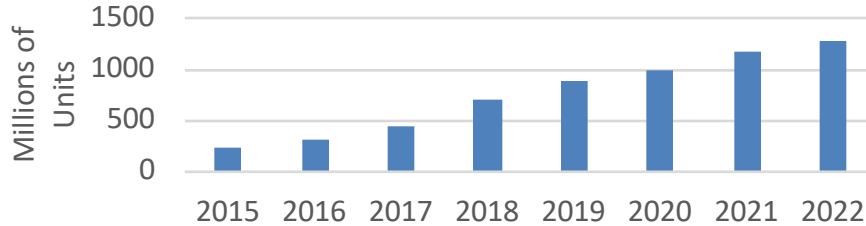
**Integrating Image, Radar, IR
and TOF Sensors:
Developing Vision Systems
with Dissimilar Sensors**

**MIPI ALLIANCE
DEVELOPERS
CONFERENCE**

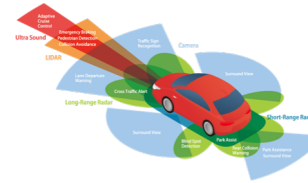
**19 OCTOBER 2018
S E O U L**

Sensors are Proliferating

Semico Research Corp.



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Automotive
27% CAGR



Drone
27% CAGR

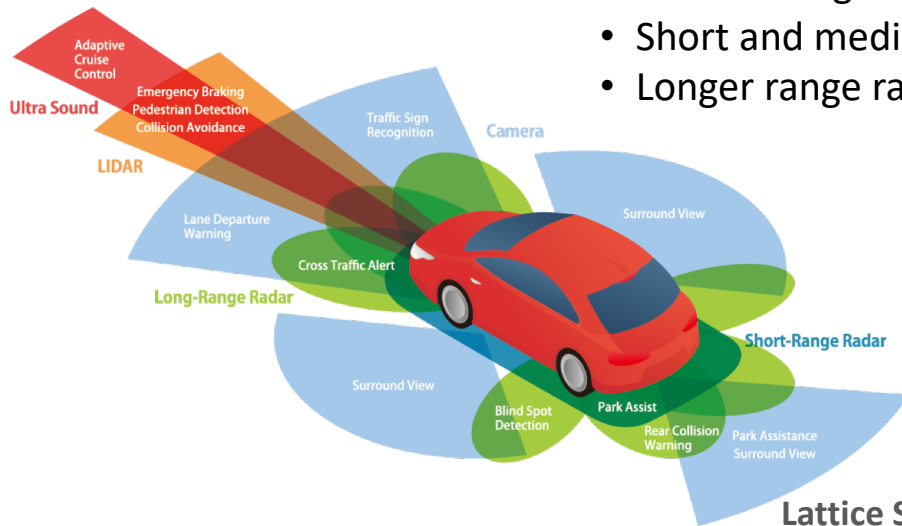


VR/AR/MR
166% CAGR

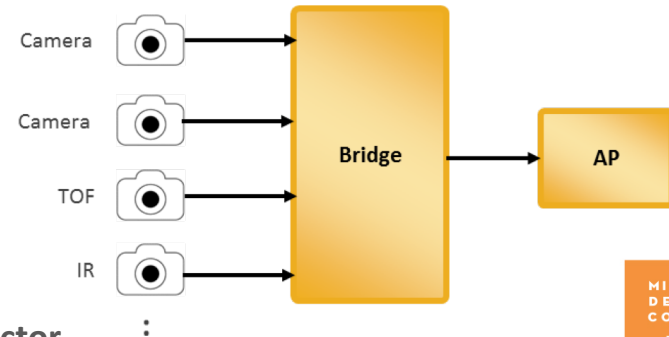
Sensors in the Automotive Environment

Lots of Dissimilar Sensors

- Imaging cameras: surround view, parking assistance and traffic sign recognition.
- Lidar: Emergency braking and collision avoidance.
- Short and medium range radar: Traffic alert and blind spot detection.
- Longer range radar: Cruise control and early forward vehicle detection.

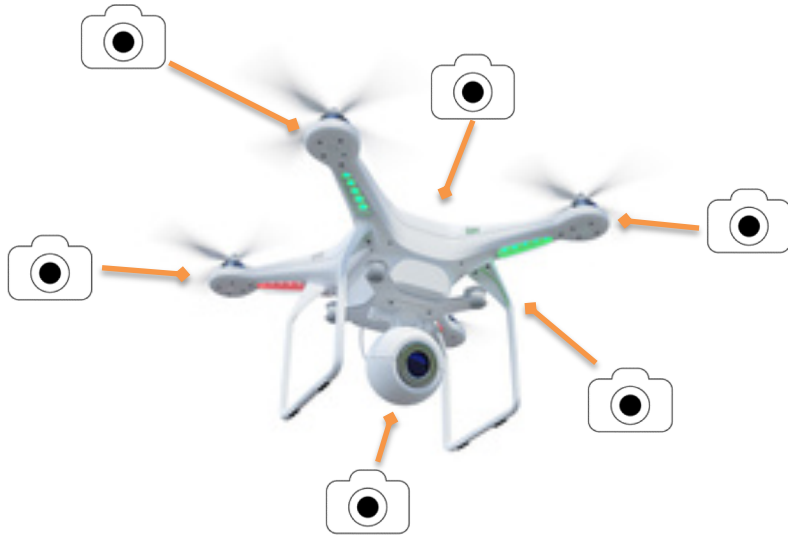


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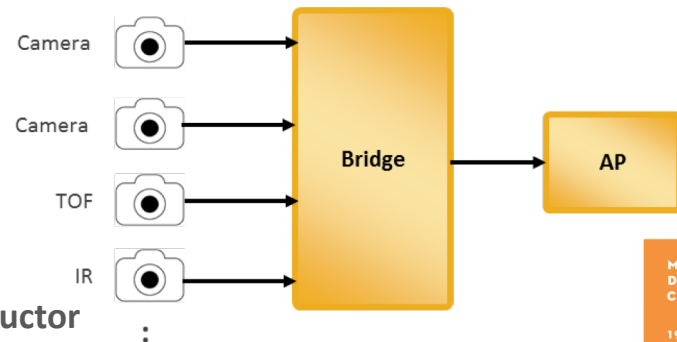


Sensors in the Drone Environment

Lots of Dissimilar Sensors



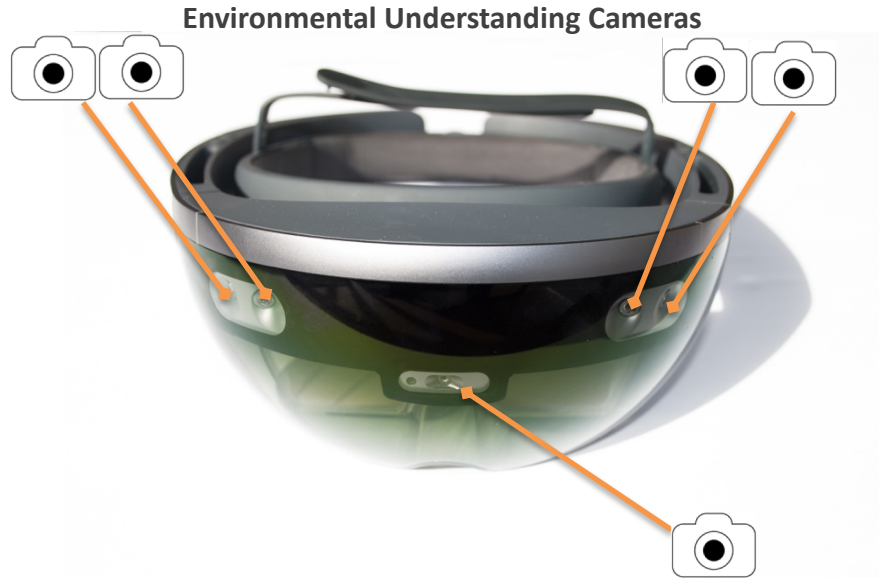
- Stereo Vision
- Ultrasonic (Sonar)
- Time-of-Flight
- Lidar
- Infrared
- Monocular Vision



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Sensors in the AR/VR Environment

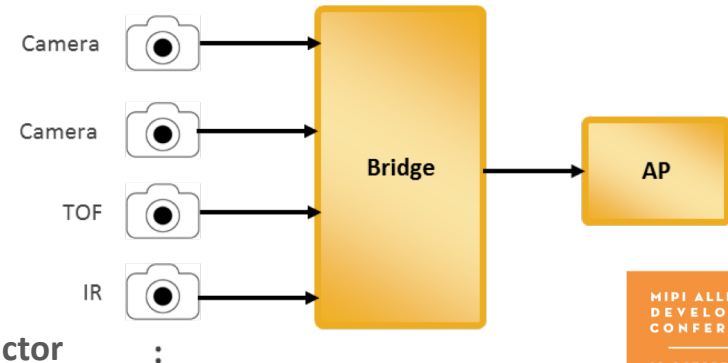
Lots of Dissimilar Sensors



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Depth Cameras

- Structured Infrared light projector/scanner
- RGB Depth cameras
- Time-of-flight camera

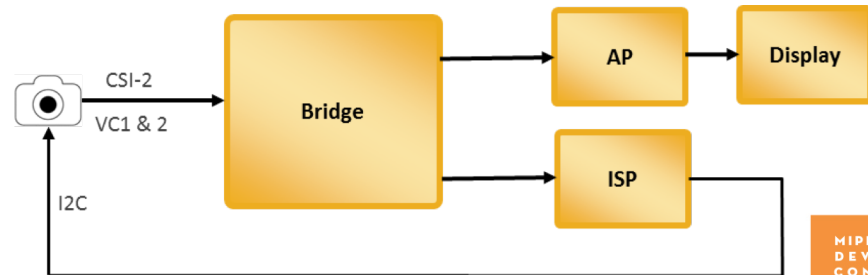
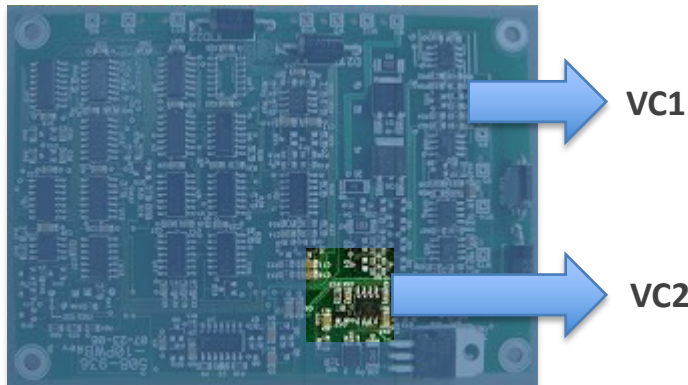


Sensors in the Industrial Environment

Cameras with Virtual Channel Capability

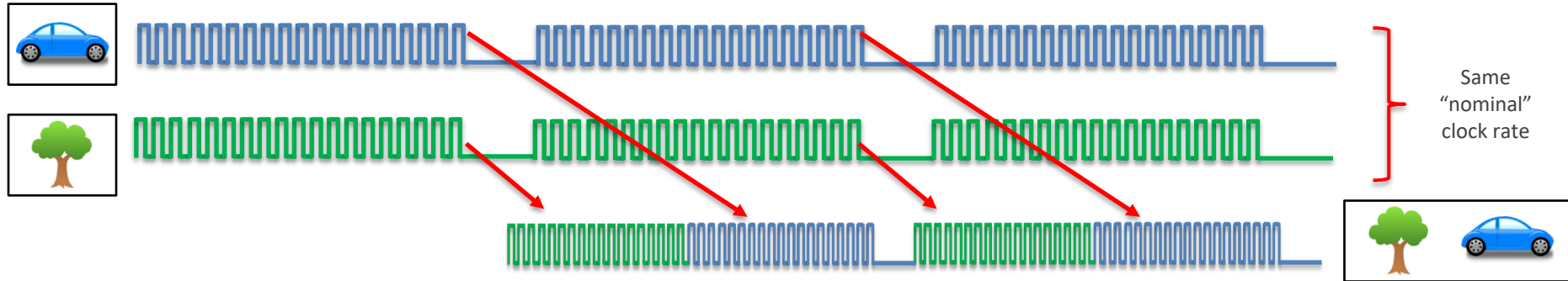


- Region of Interest
- Down sampling
- Virtual Channels



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Combining Identical Sensors

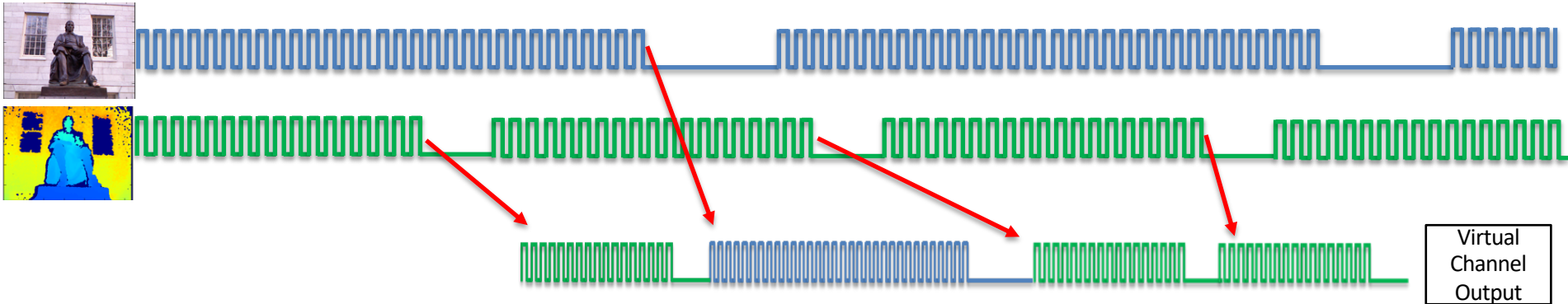


- Sync Sensors
- Buffer Lines
- Concatenate both lines at 2x frequency

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Combining Dissimilar Sensors

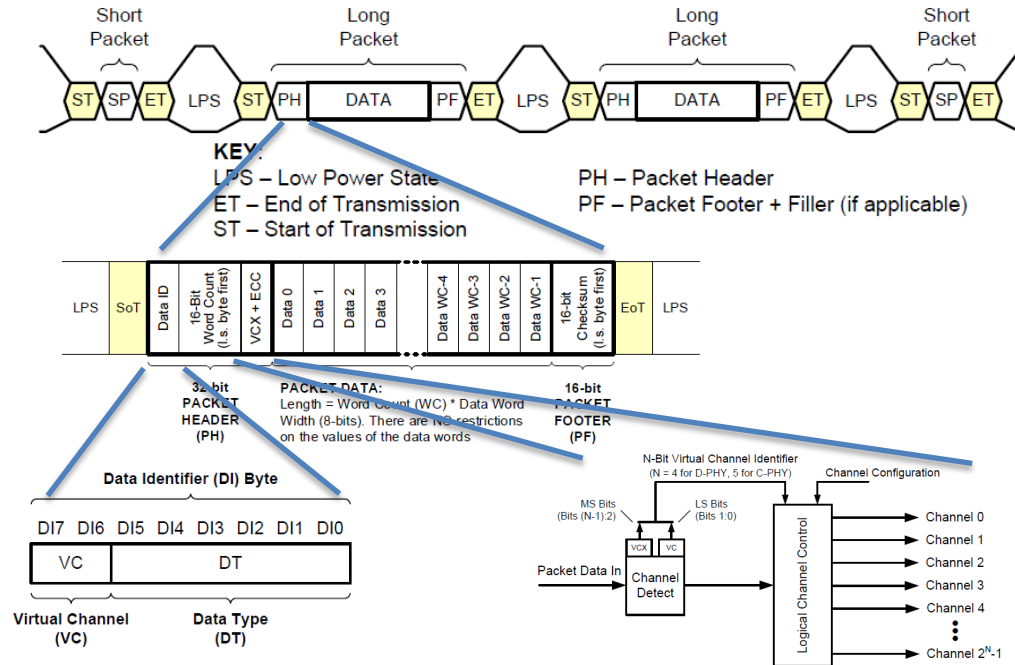
Different Data Rates



- Sensors not synchronized
- Different Clocks
- Output Frequency \geq Input 1 + Input 2
- Lines sent out FIFO via Virtual Channels

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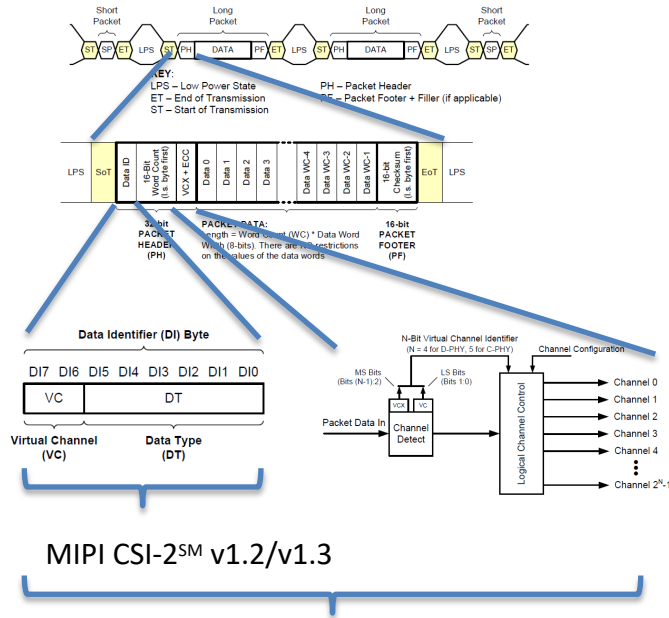
MIPI CSI-2SM Virtual Channels (VC)



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Challenges – Virtual Channel (VC) Fields

Different VC Mappings between Different MIPI CSI-2SM Versions



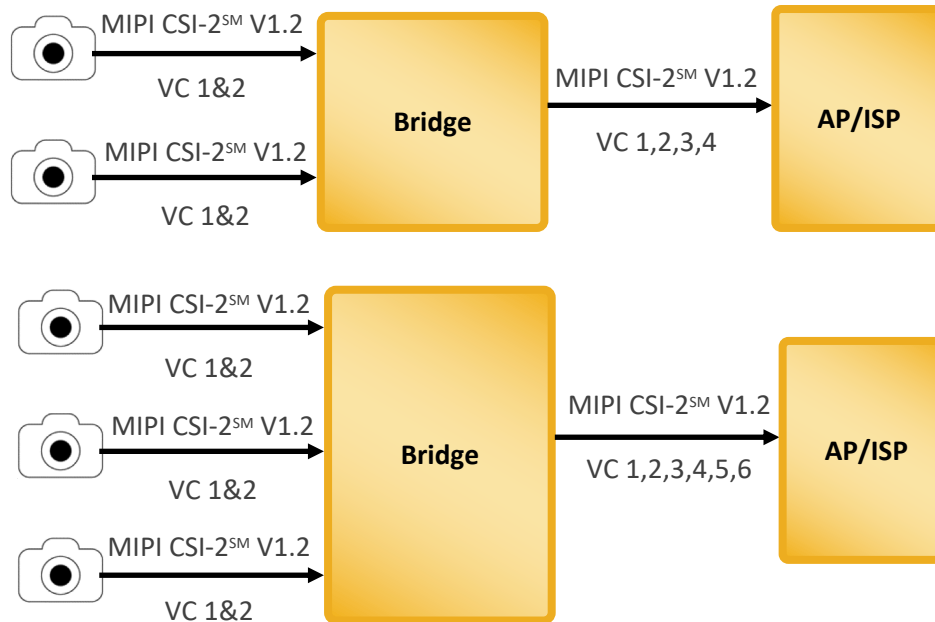
MIPI CSI-2SM v2.0

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KEY issue: difference in supported MIPI CSI-2SM version

- MIPI CSI-2SM v1.2/v1.3 - only supports up to 4 slaves (2-bit VC)
- MIPI CSI-2SM v2.0 - can support up to 16 or 32 slaves (4-bit VC for MIPI CSI-2SM over D-PHY , 5-bit VC for MIPI CSI-2SM over C-PHY)

Challenges – VC Fields



If there are no more than 4 input channels:

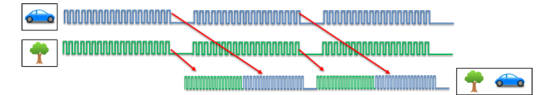
- Bridge can perform simple mapping to MIPI CSI-2SM V1.2.

If there are more than 4 input channels:

- Bridge can perform simple mapping to MIPI CSI-2SM V2.0.

- If processor cannot support MIPI CSI-2SM V2.0:

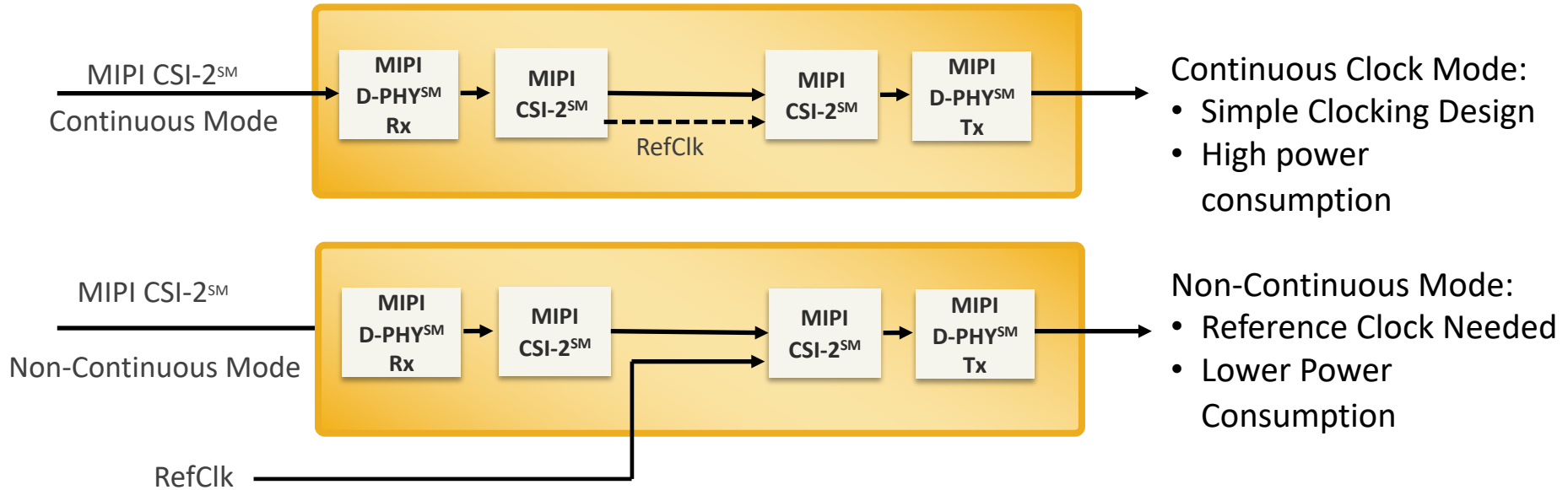
- Must merge similar sensors into one stream



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Challenges – Clocking

Continuous vs. Non Continuous Modes for MIPI CSI-2SM

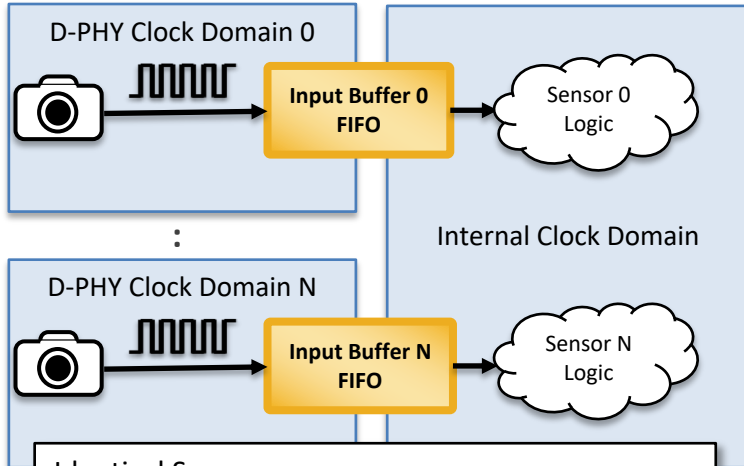


- Continuous Clock Mode:**
- Simple Clocking Design
 - High power consumption

- Non-Continuous Mode:**
- Reference Clock Needed
 - Lower Power Consumption

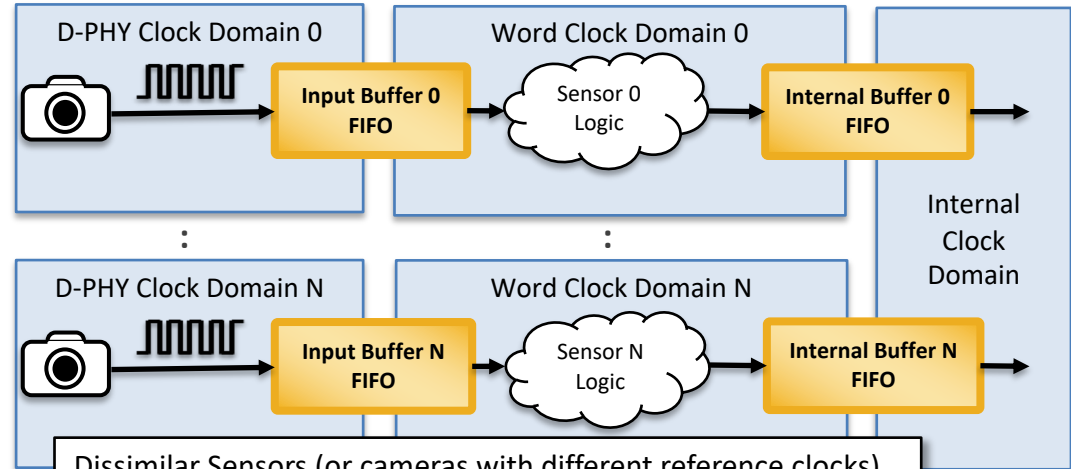
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Challenges – Multiple Clock Domains



Identical Sensors

- Can use common reference clock
- Separate Clock Domains
- FIFO Resolves Meta-Stability
- Internal Circuitry employs simple buffering adjusting for clock phasing



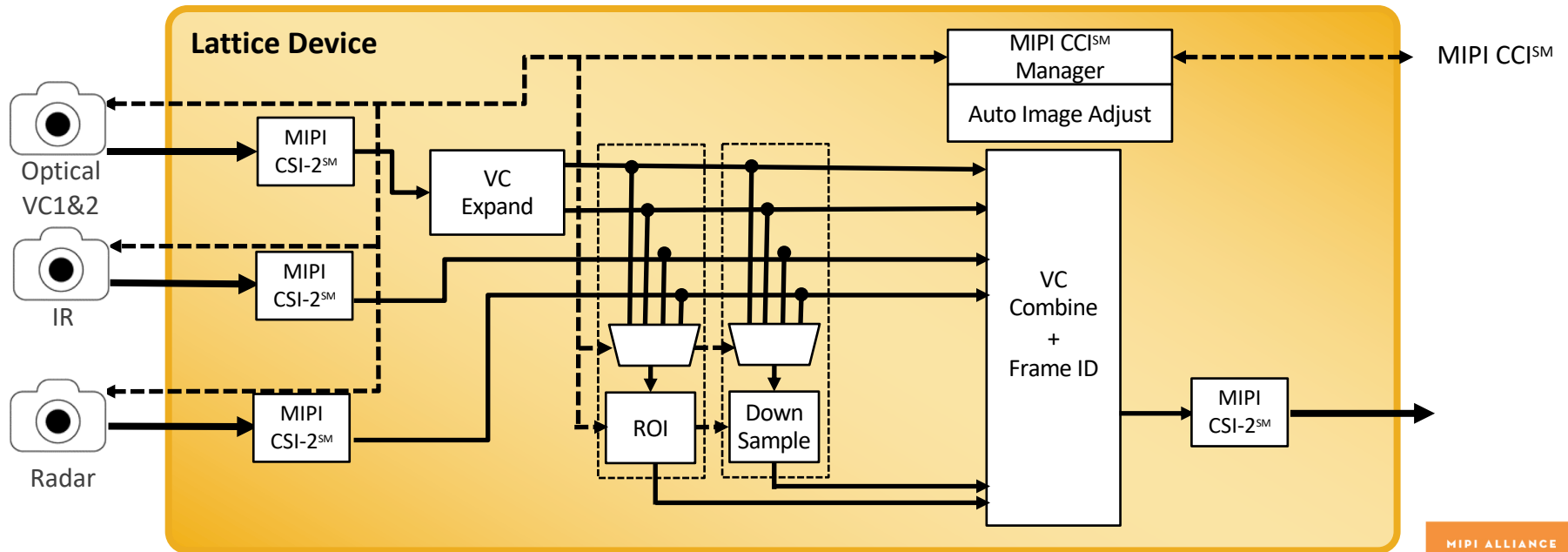
Dissimilar Sensors (or cameras with different reference clocks)

- First clock domain referenced to source clock
- Second clock domain referenced to word clock.
- Third clock domain referenced to internal clock

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Virtual Channel Pre-Processing in Hardware

Balancing Power and Performance

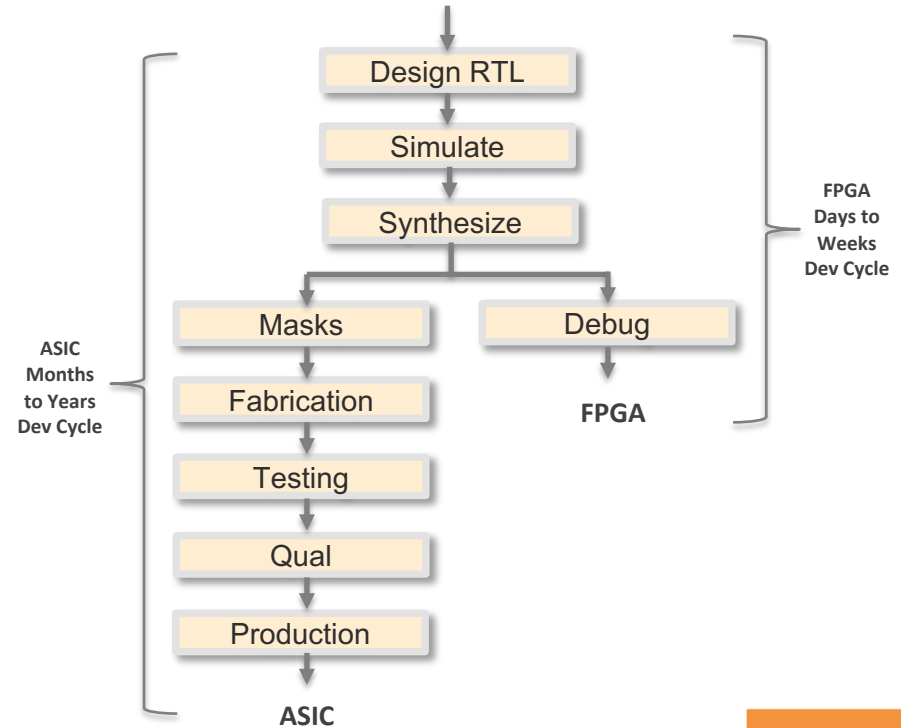


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Why FPGAs?

- Product Development Cycle
 - Faster time to Market
 - Lower NRE
 - Enable Innovation
- Size
 - Pin constrained – same as ASIC
- Power
 - Largely a function of Interfaces

Fewer and fewer designs are using ASICs



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ADDITIONAL RESOURCES

- MIPI Camera WG:
<https://members.mipi.org/workgroup/join/154>
- MIPI CSI-2SM V2.1: <https://members.mipi.org/wg/All-Members/document/folder/11134>

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