AIMOTIVE

Optimal scheduling in a multi-GPU environment

2019/07/11

Agenda

- Simulation for self-driving
  - Limitations of game engines
- Synthesizing camera images
- Sensor system and scheduling
  - CPU Scheduler
  - GPU Scheduler

Simulation for self-driving

Simulation for self-driving

- Safe operation of self-driving systems requires large-scale testing
- Huge distances must be covered in various road conditions and environments
- Limited testing possibilities in the real world
- Simulators provide great tools to satisfy these requirements

Simulation for self-driving

- Simulators must be comprehensive and robust :
  - Diversity of maps, environments, conditions and driving cultures
  - Repeatability of tests and scenarios
  - Pixel-precise deterministic rendering
  - Physical realism
  - Ready-access for self-driving developers and engineers
  - Efficient use of hardware resources, from laptops to servers

Limitations of game engines

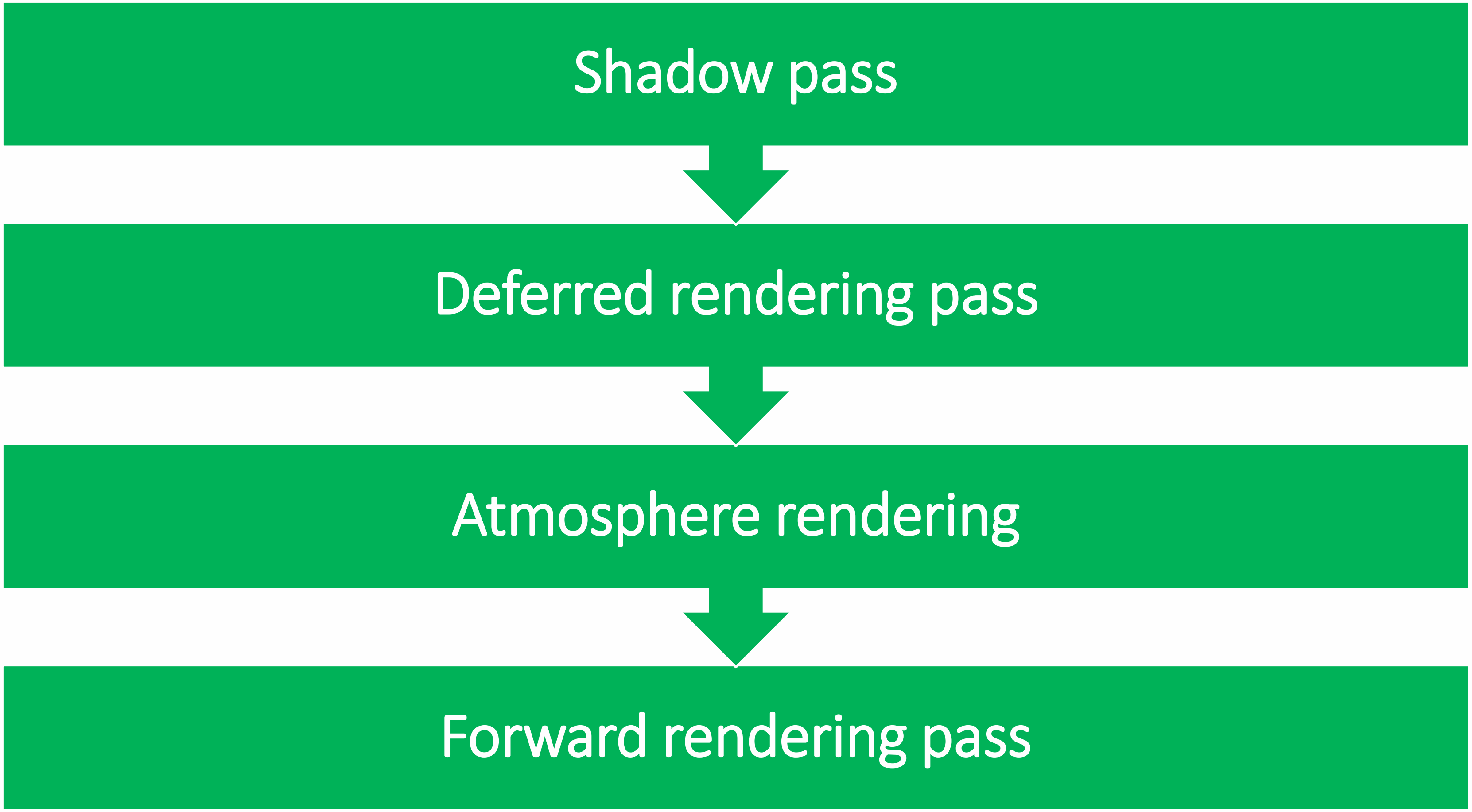
- Several problems encountered with first, game engine based simulator
  - Rendering images produced by ultra-wide and narrow camera lenses required certain modifications
  - Performance issues
  - Artifacts occurred in post-process effects
  - No support for using multiple GPUs
- These specific demands cannot be answered efficiently by game engines
- First iteration supported formulating the specifications mentioned
  - Especially for the sensor system and camera pipeline

Synthesizing camera images

Synthesizing camera images

- Problem of simulating lenses
- GPU rasterization-based rendering pipeline
  - Ray-tracing might be an option for simulating lenses in the future
- Vulkan based graphics backend
  - Multi-platform
  - Multi-GPU
- Complex rendering pipeline
  - First phase: environment capture (PBR pipeline)
  - Second phase: camera lens distortion
    - Pinhole, Fisheye

Environment capture



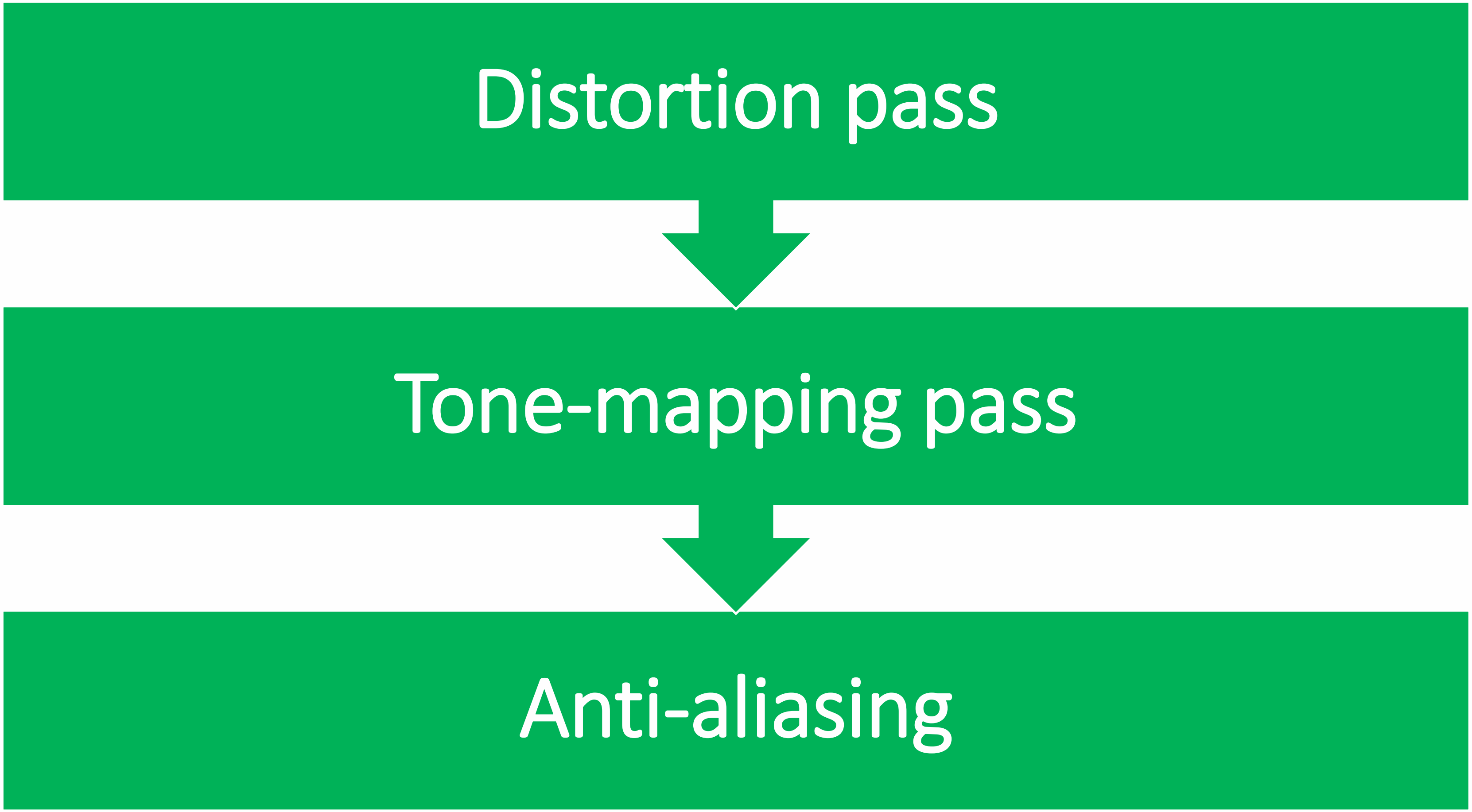
Shadow pass

Deferred rendering pass

Atmosphere rendering

Forward rendering pass

Distortion and post-process



Distortion pass

Tone-mapping pass

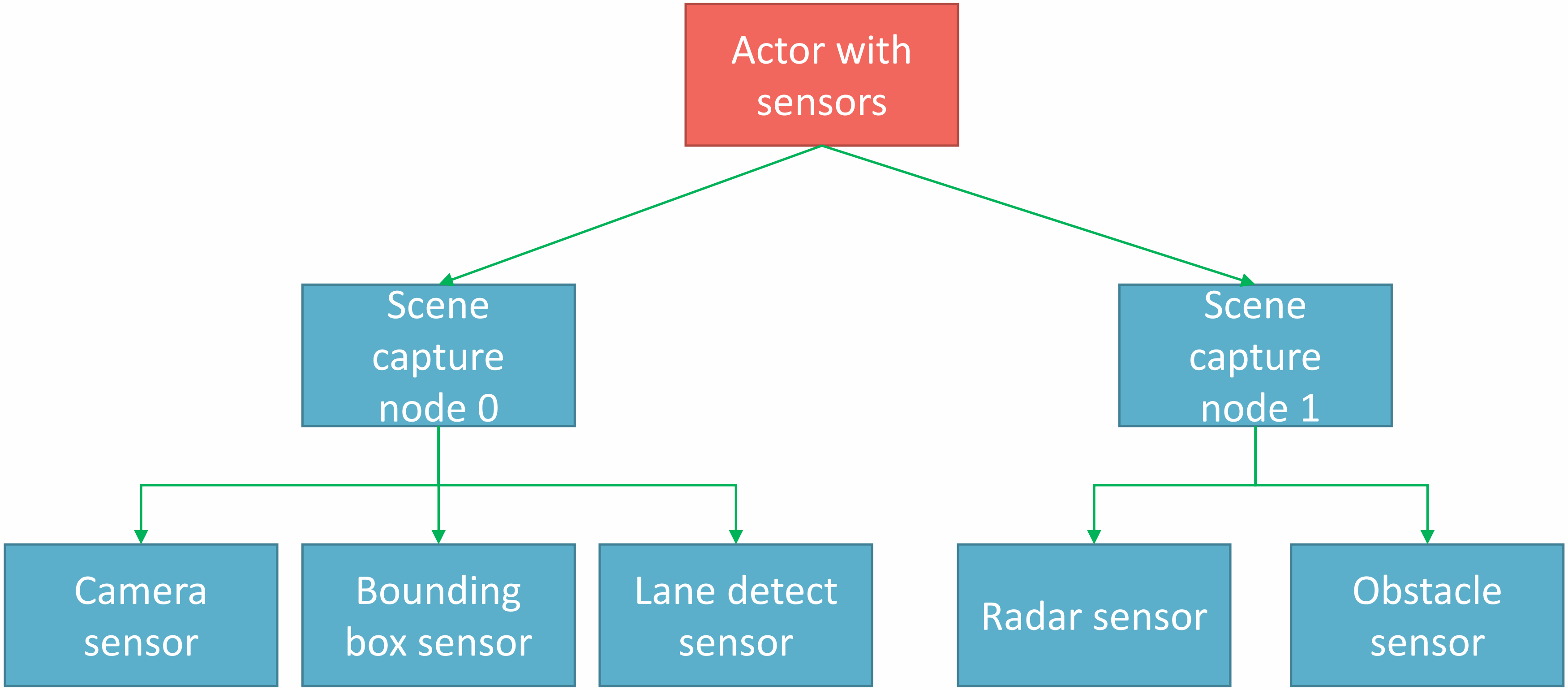
Anti-aliasing

Sensor system and scheduling

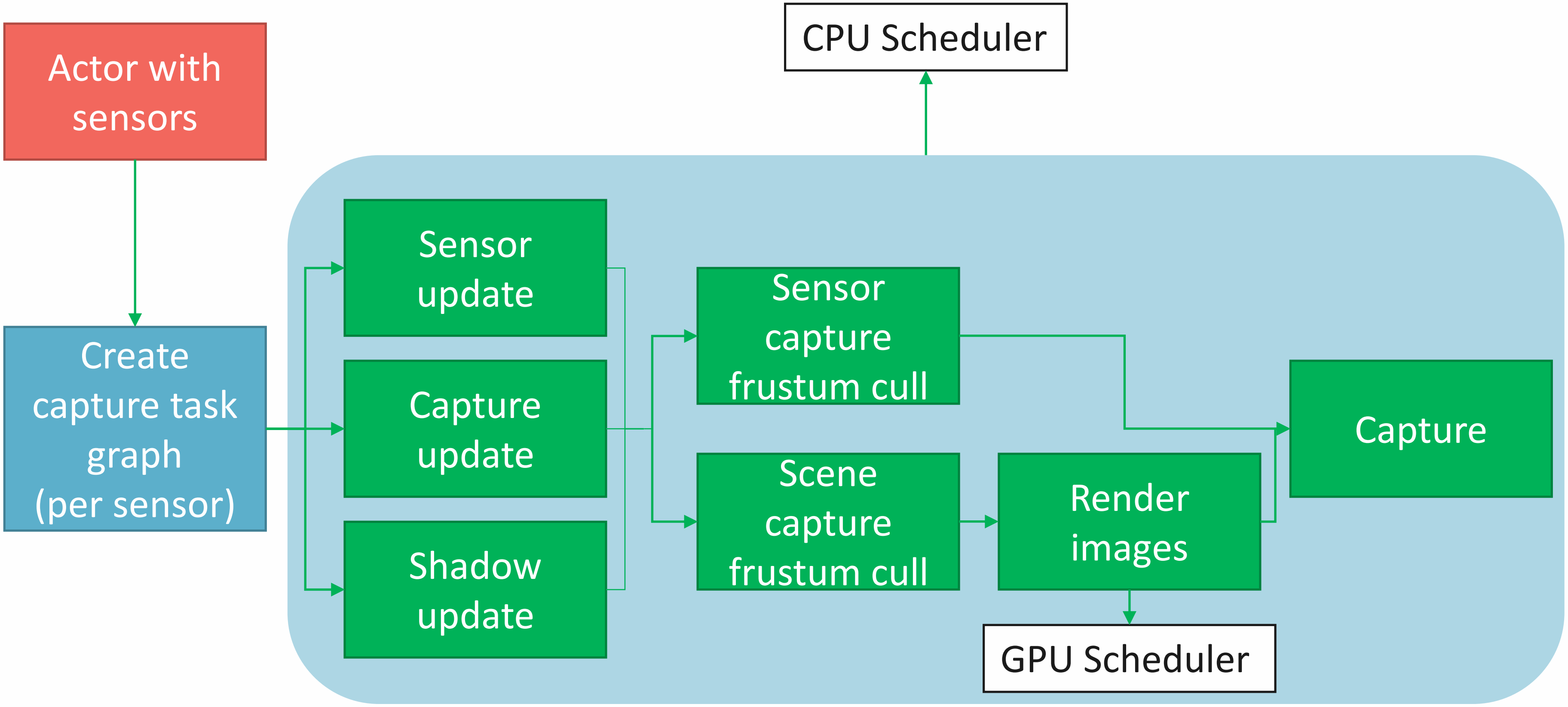
Sensor system and scheduling

- Our simulated world is a graph
  - Virtual objects
  - Hierarchy of various types of nodes (actor-, capture-, mesh-, etc. nodes)
- Basic concept of the sensor system
  - Scene capture nodes can be attached to actor nodes
  - These capture nodes provide data for their sensor nodes
- Resource management
  - Executing sensor tasks on CPU cores
  - Distributing rendering tasks among multiple GPUs
  - We implemented CPU- and GPU schedulers for this purpose

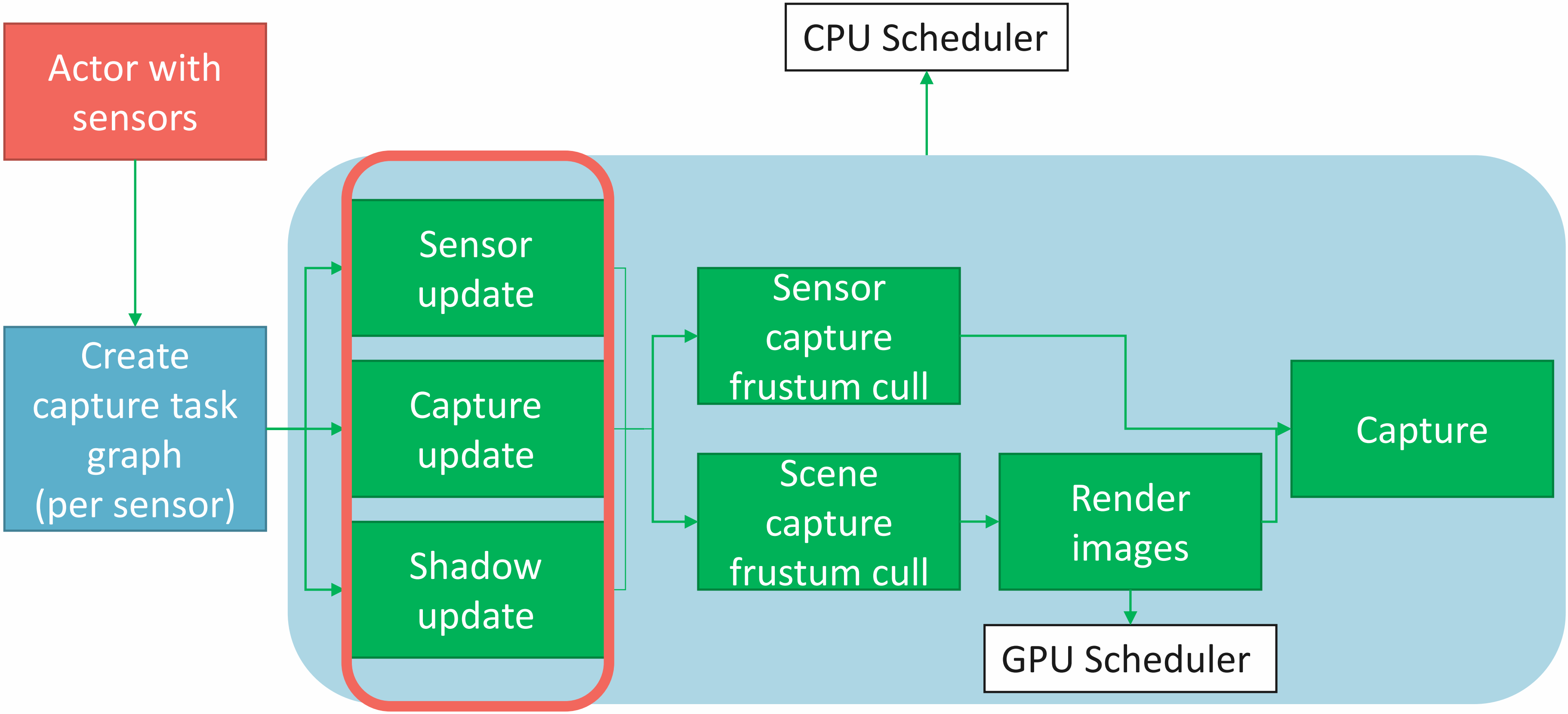
Typical sensor setup



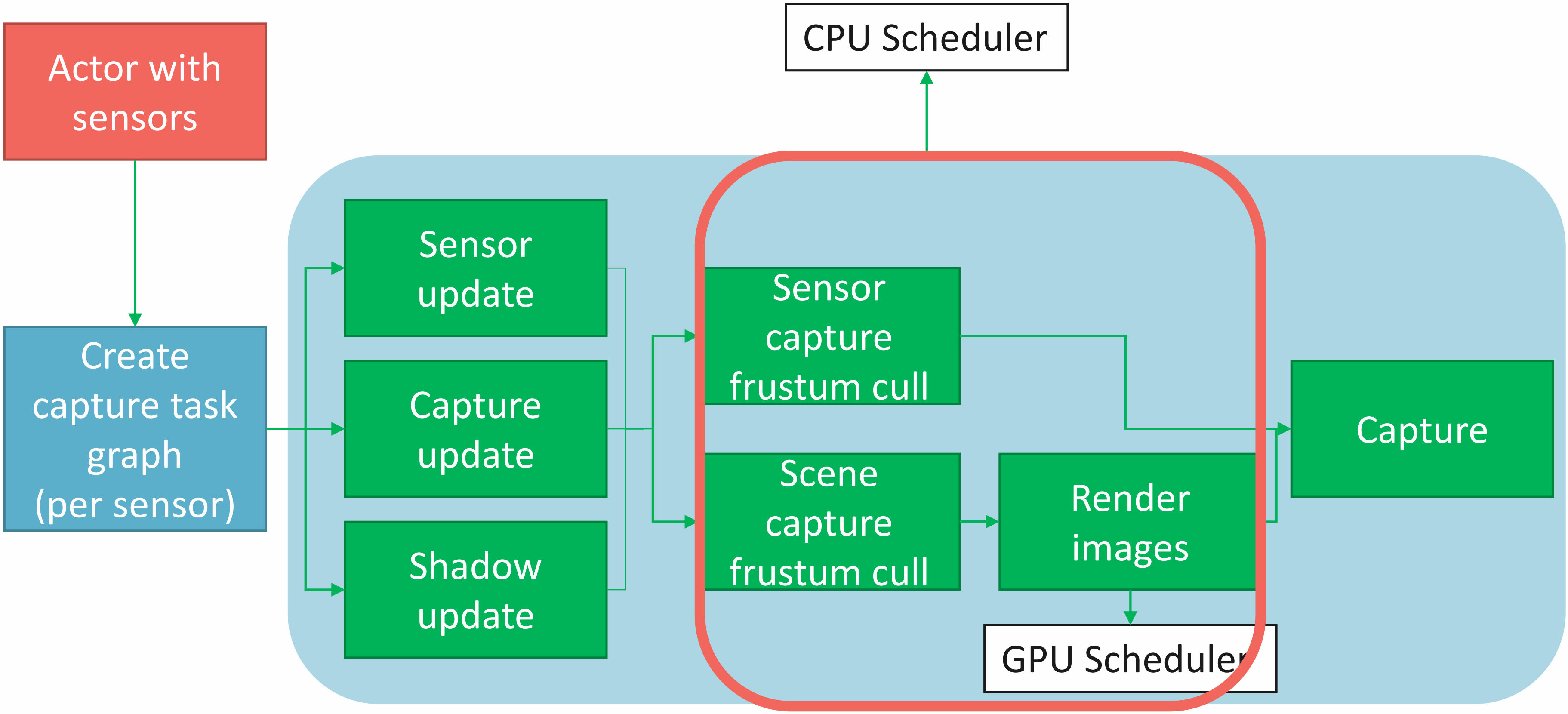
Sensor task graph



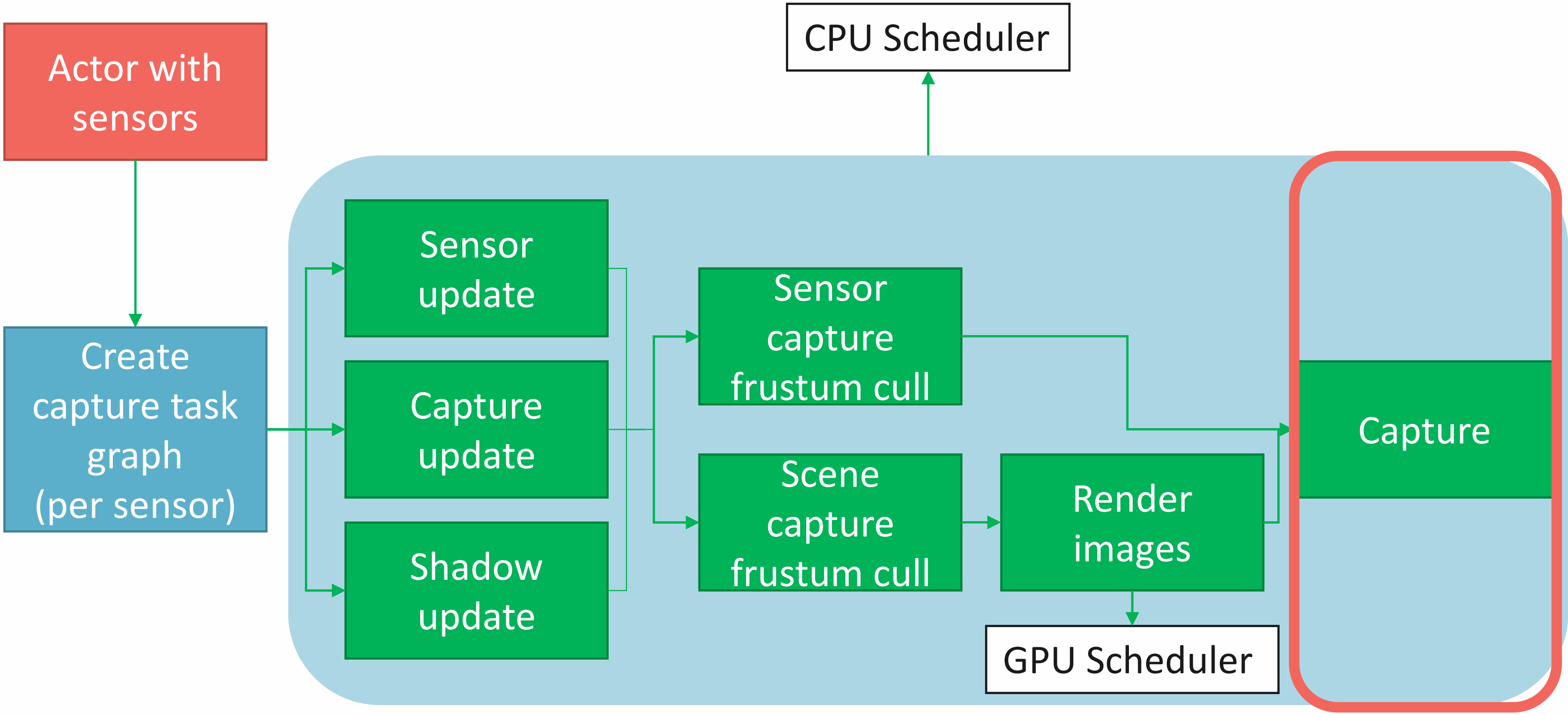
Sensor task graph



Sensor task graph



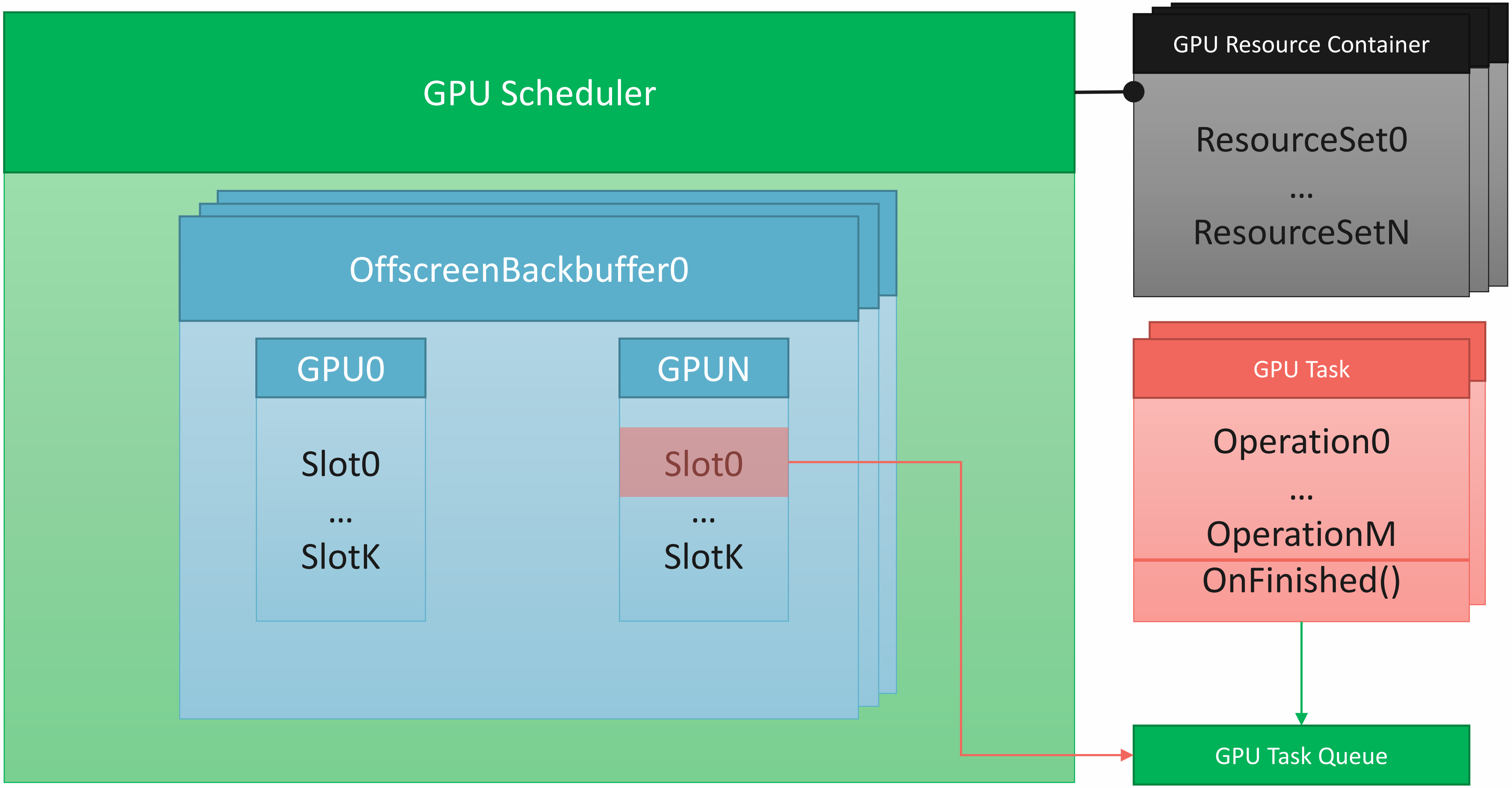
Sensor task graph



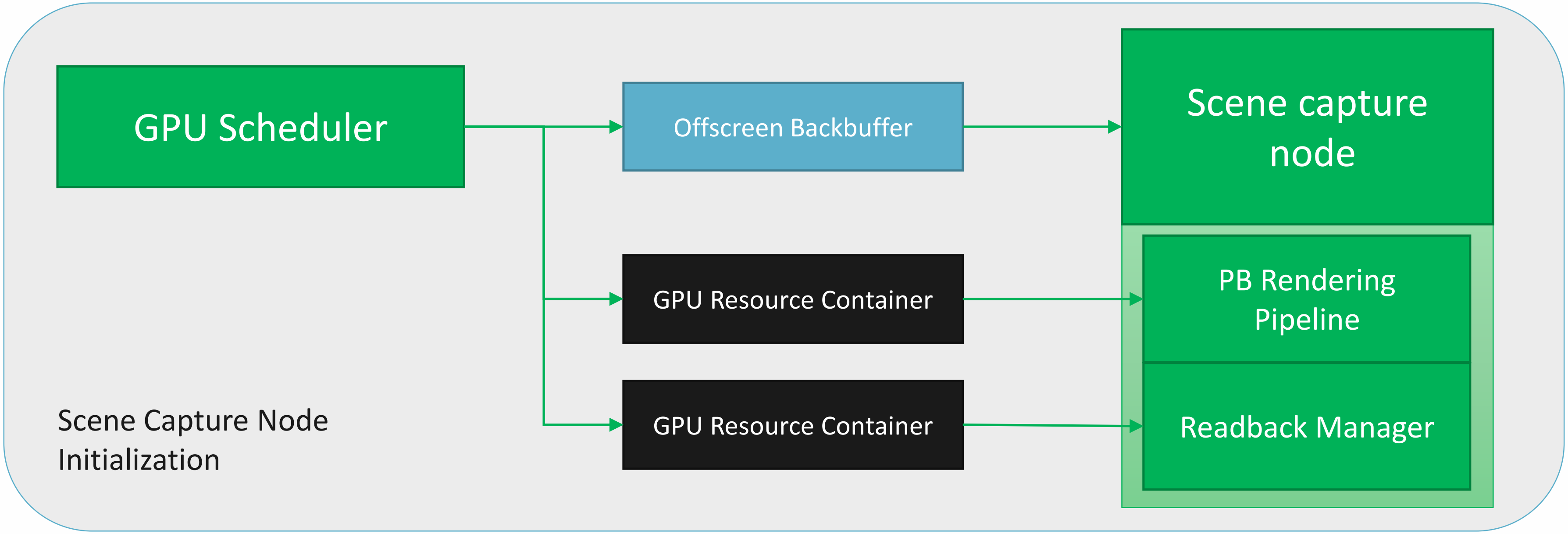
Rendering images

- Rendering
  - RGB-, Bayer images
  - Segmentation, Distance images
  - Etc.
- Two main phases
  - Executing rendering operations
  - Readback from devices
- GPU Scheduler
  - Manages GPU resources
  - Chooses a GPU slot for a task
- Definitions
  - GPU Slot – An operation buffer on a specific GPU
  - GPU Task – Subset of GPU operations in a GPU Slot
  - GPU Task Queue – Set of GPU Tasks, submission to GPU

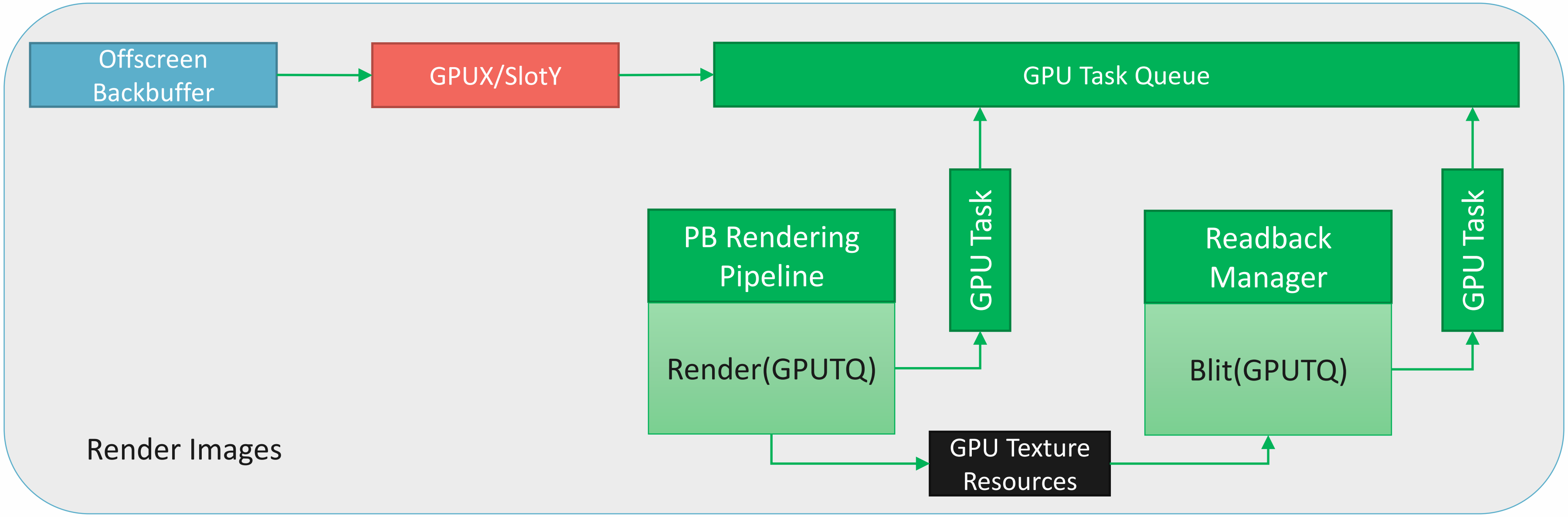
GPU Scheduler Architecture



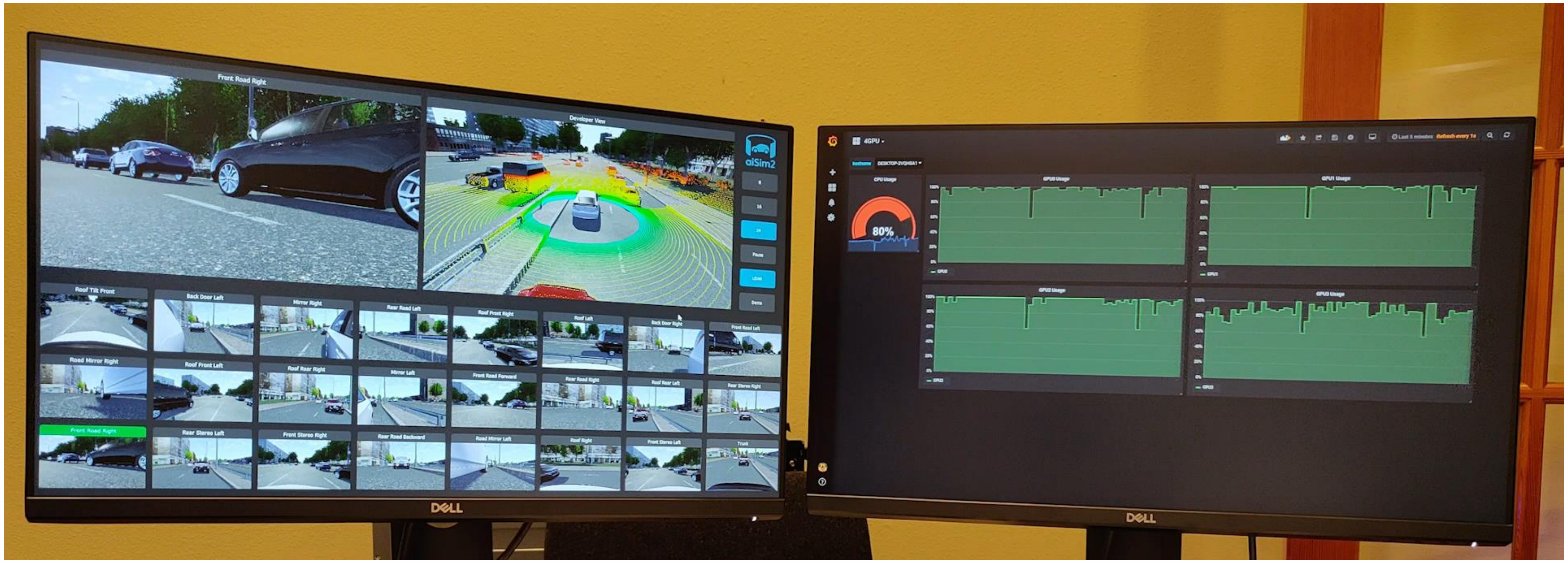
Initialization



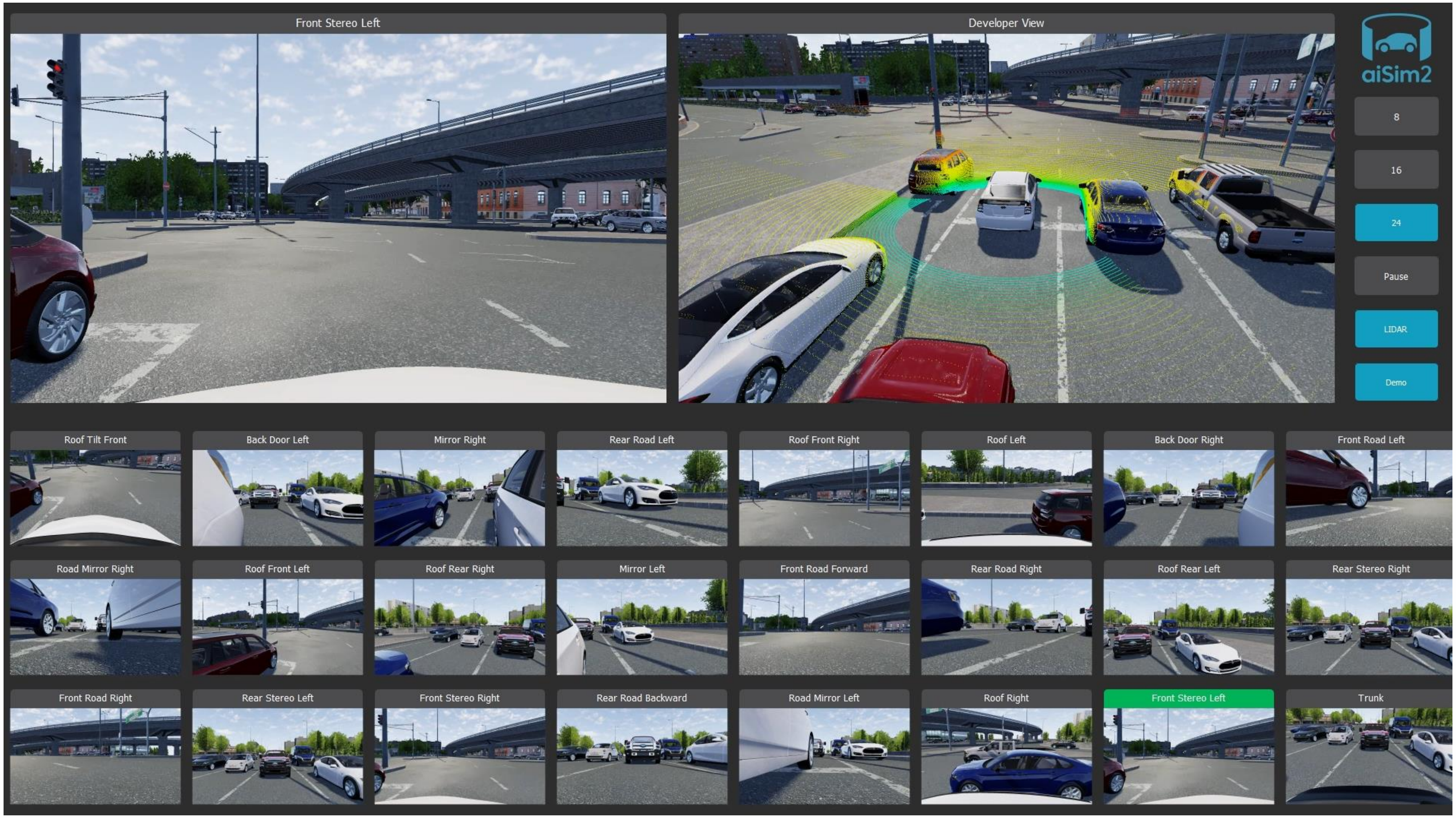
Initialization and Render Images



What we achieved?



What we achieved?



What we achieved?

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Thank you for your attention!

Do you have any questions?