Accelerated Packet Processing Based on Nvidia Bluefield DPU

Day Final - Team 6 NTHU_LSALAB

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Team Name

Team 6 NTHU_LSALAB

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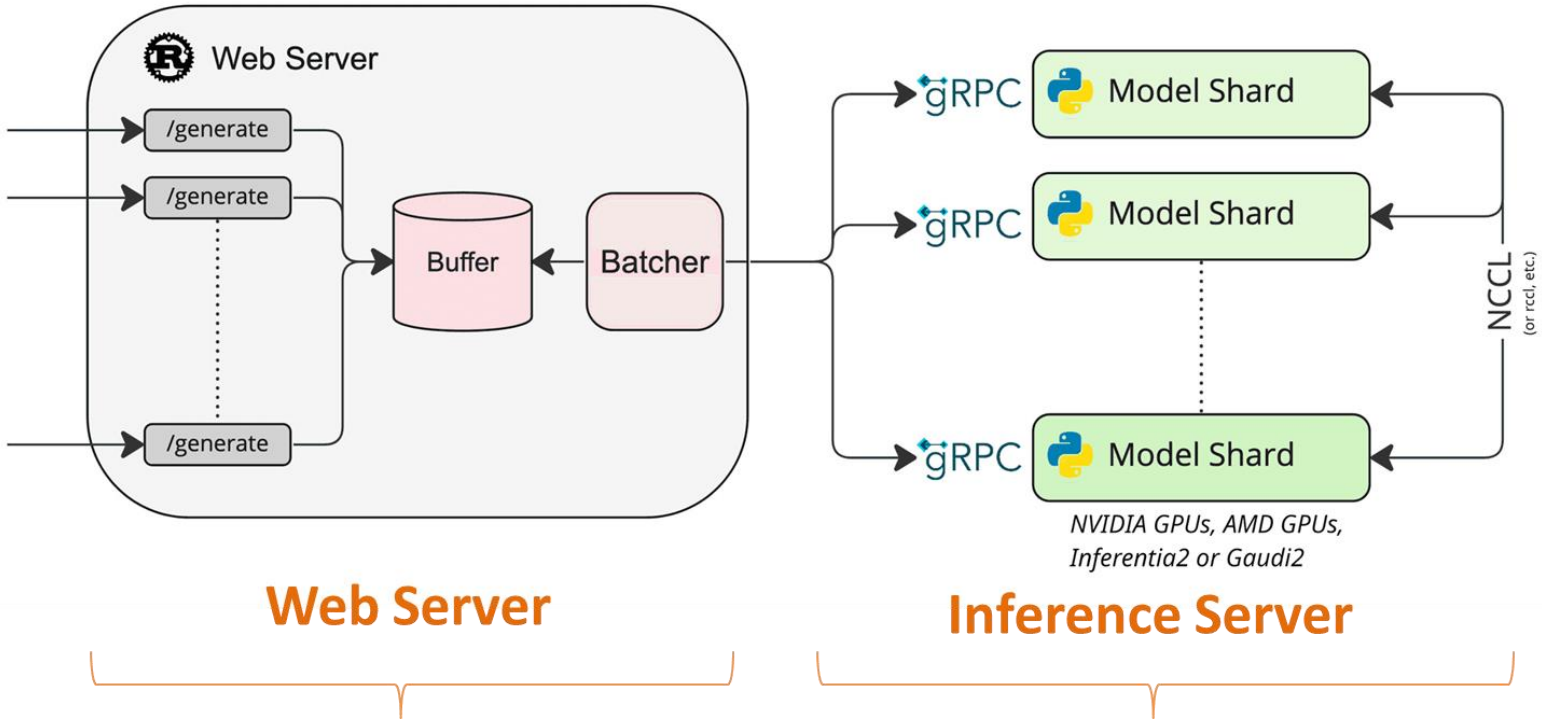
NVIDIA

Can we accelerate inference server?

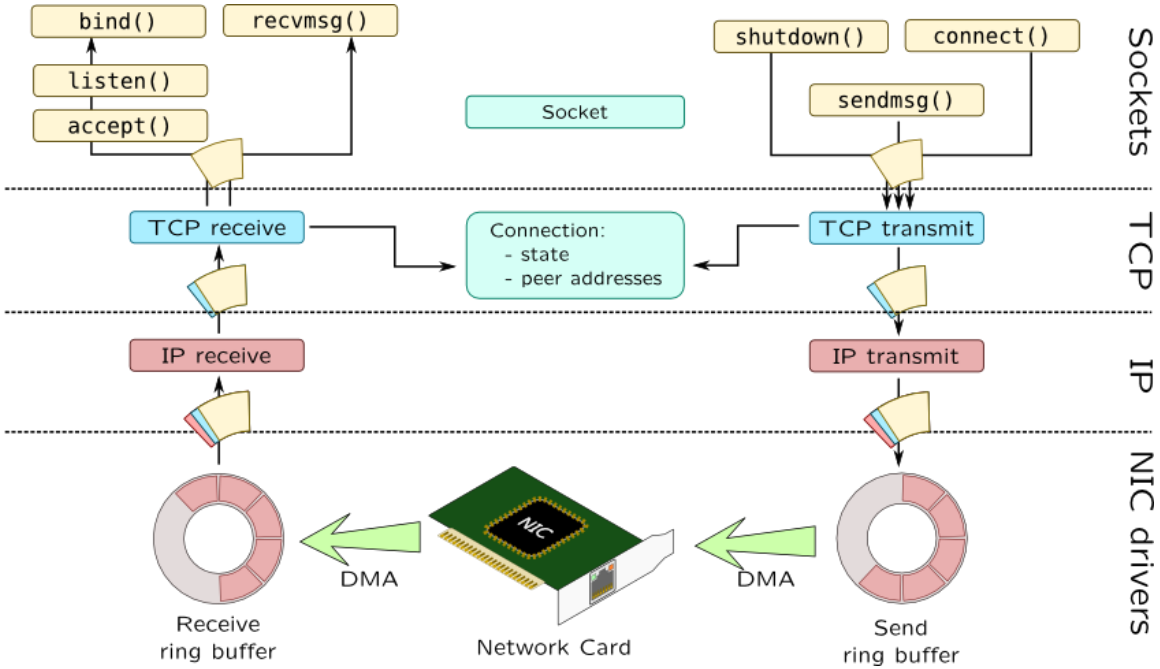
Problem the team is trying to solve.



Can we accelerate the inference process?

CPU Packet Processing

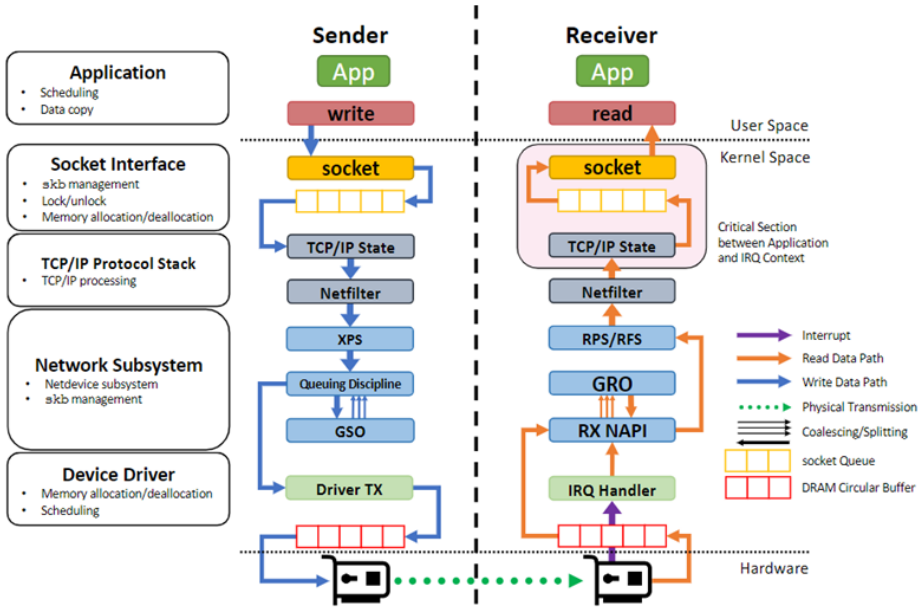
Packet processing refers to the operations performed by a processing unit to handle network packets, including tasks such as packet forwarding, classification, inspection, and transformation based on specific protocols or rules.



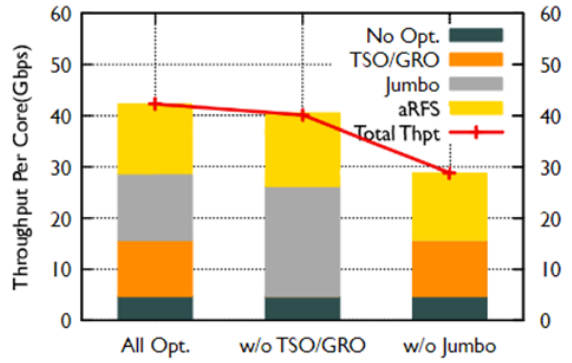
- The most commonly used processing unit for network tasks is the CPU
- Which works in conjunction with the network subsystem.

The limitations of CPU

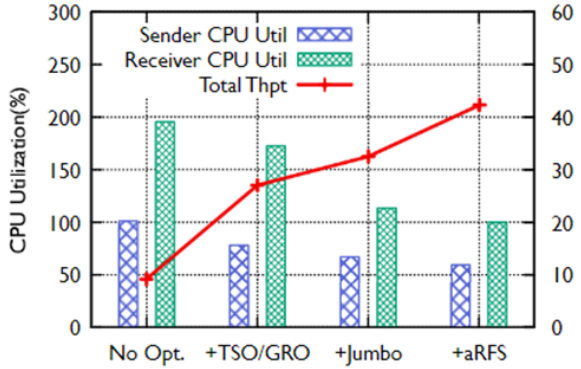
Process a packet is a heavy task.



The era of 100Gbps is coming.



(a) Throughput-per-core (Gbps)



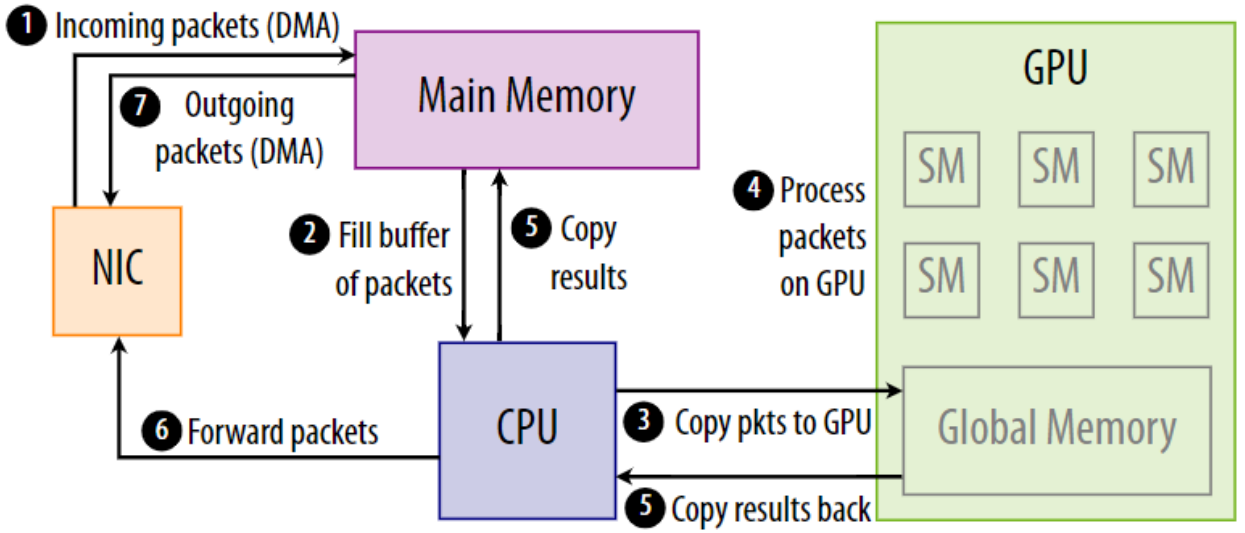
(b) CPU utilization (%)

⇨ A single core is no longer sufficient.

⇨ Receiver-side CPU is the bottleneck.

Source:https://dl.acm.org/doi/10.1145/3452296.3472888

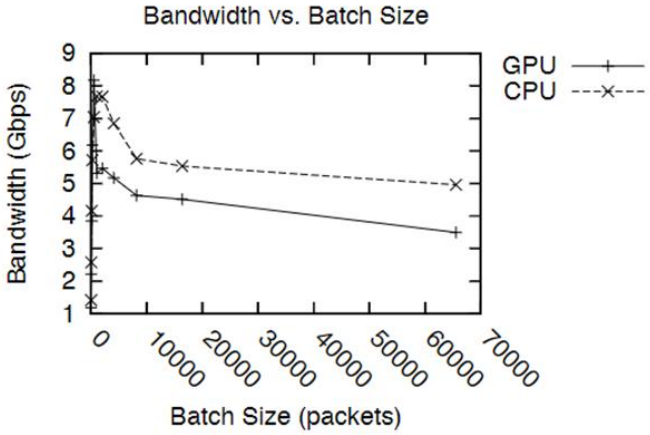
Packet Processing on the GPU



Since GPU are strong in processing, the throughput are willing to be raised.

CPU-GPU Based Processing

The devil is in the experiments.



Although it spends less time processing, **it has to copy packets to the GPU for processing and copy the results back.**

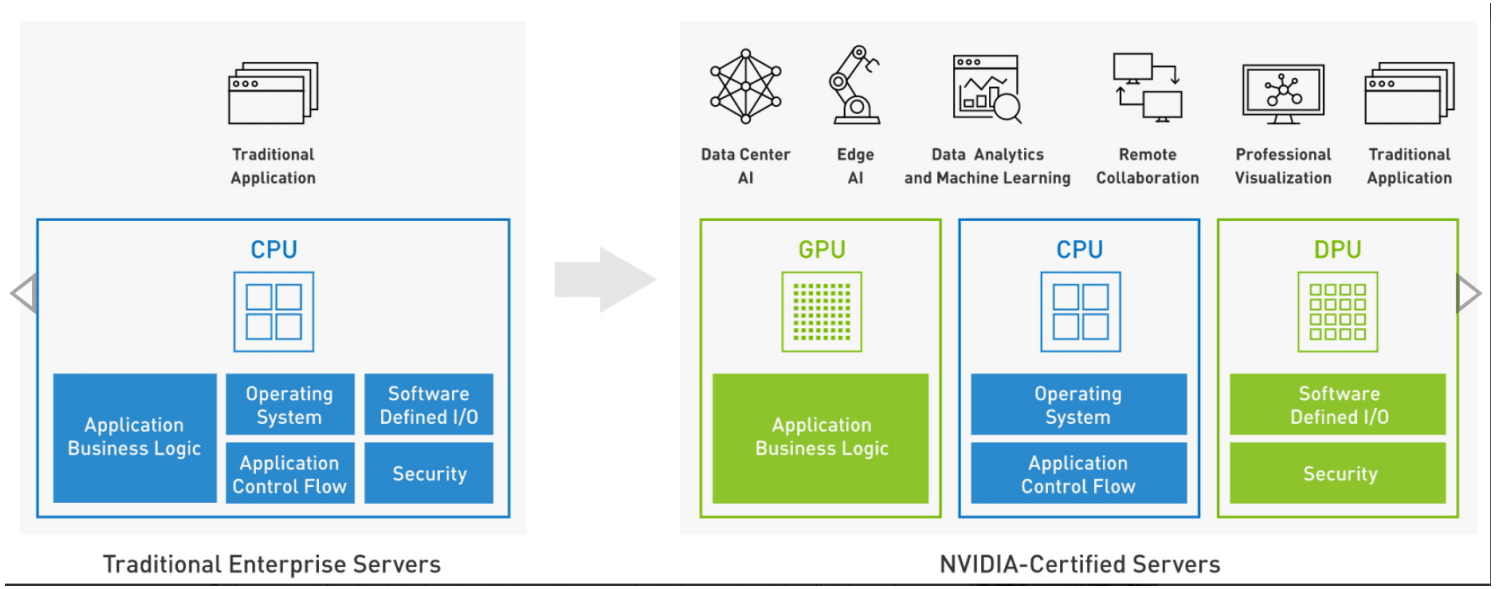
What if, we can transfer packets without CPU?

Source:https://www.cs.cmu.edu/~bvavala/misc/project740/15-740_Project_files/Report.pdf

Data Process Unit

What was your initial strategy?

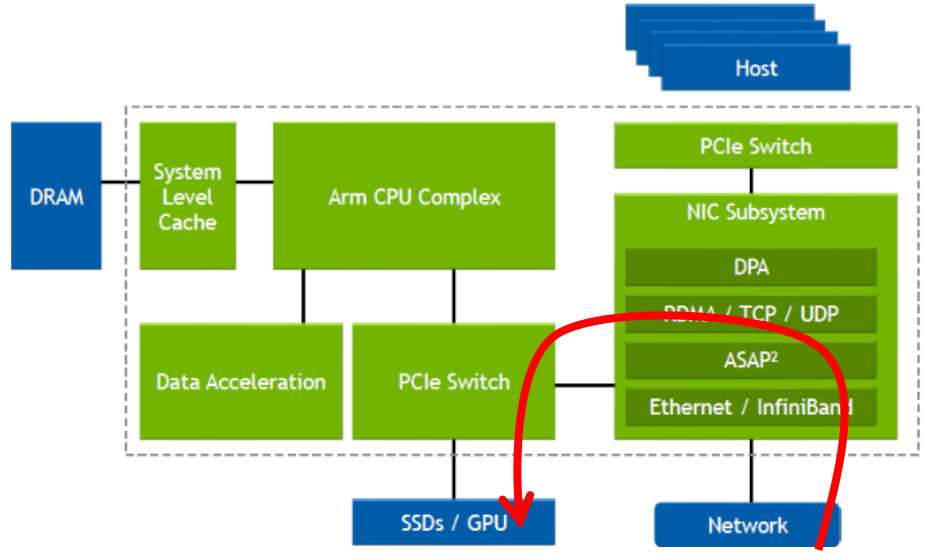
- Data Processing Unit (DPU) is a pivotal component in the realm of advanced computing architectures.
- A new class of programmable processor and will join CPUs and GPUs as one of the three pillars of computing.



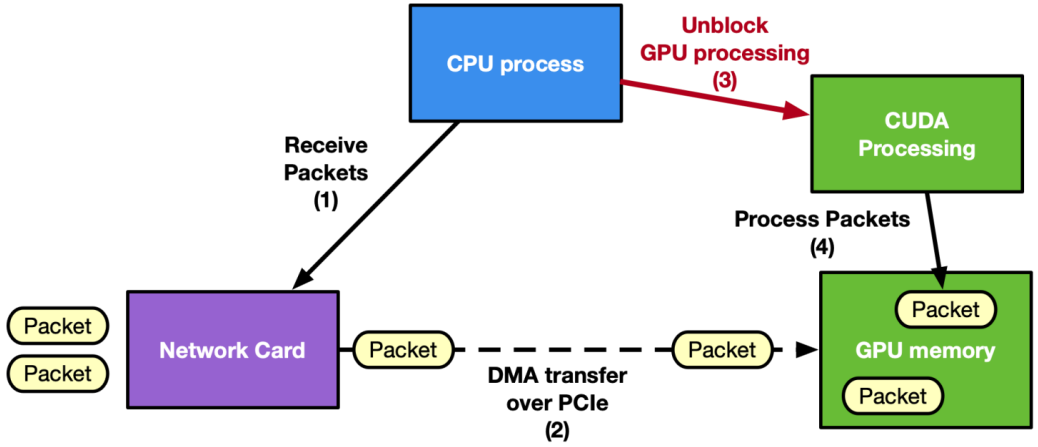
- **An enhanced SmartNIC for Network Processing.**
- **A bridge between NIC to CPU/GPU.**

DPU System Architecture

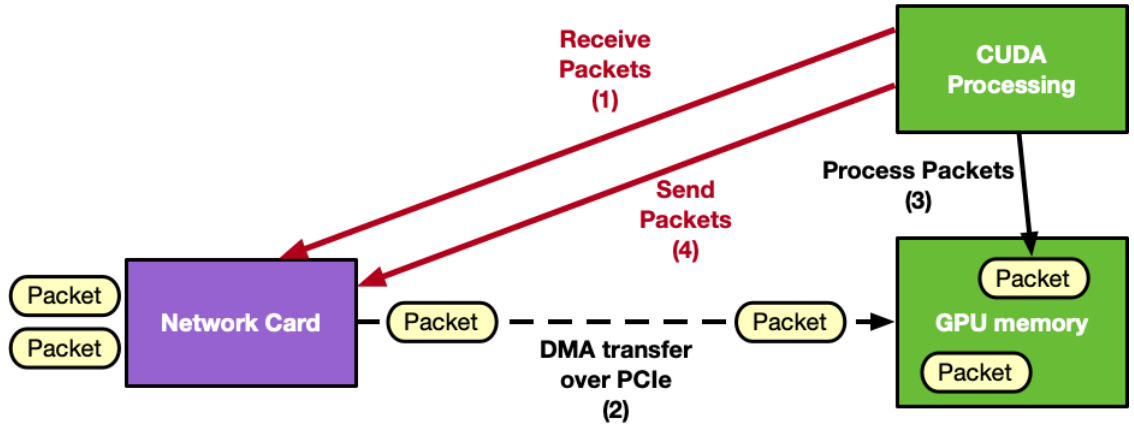
- **DPU utilized the same subsystem from existing kernel.**
- **The best part of DPU is programmable.**



Before: CPU-Centric



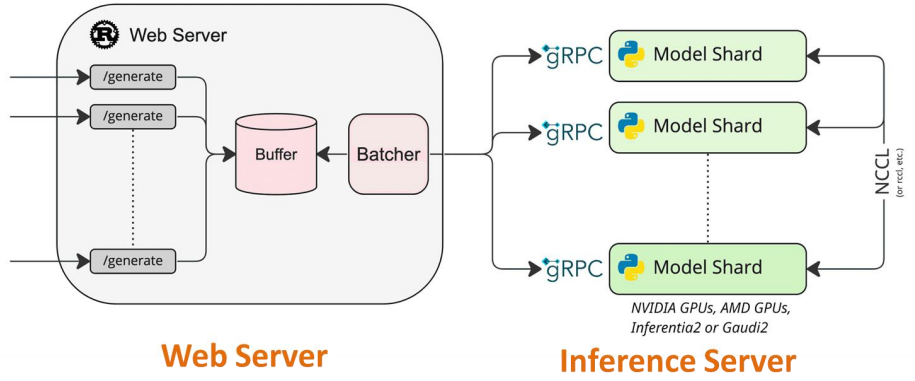
After: GPU-Centric



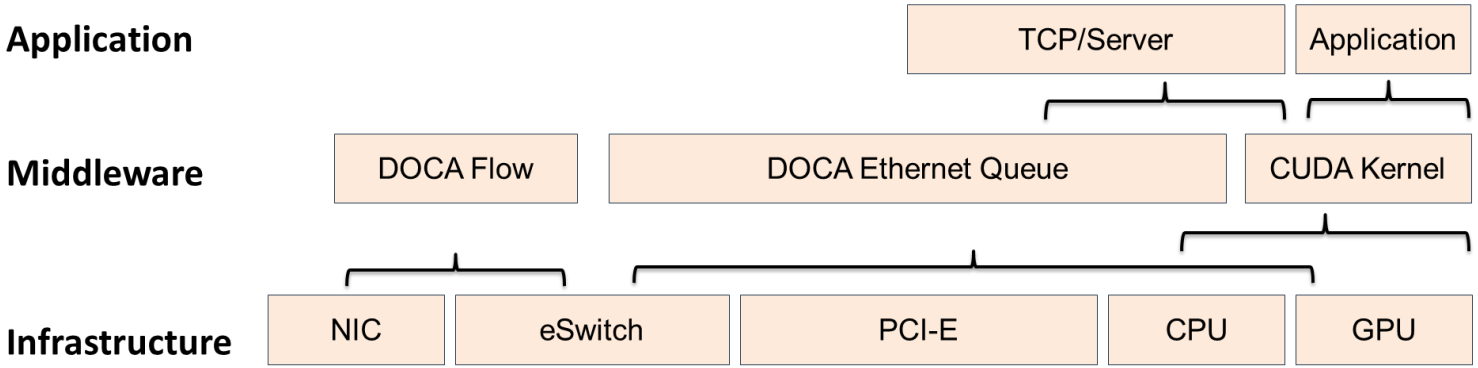
The devil is in the experiments again.

What was your initial strategy?

Problem: Web Server consumes CPU resource on inferencing.



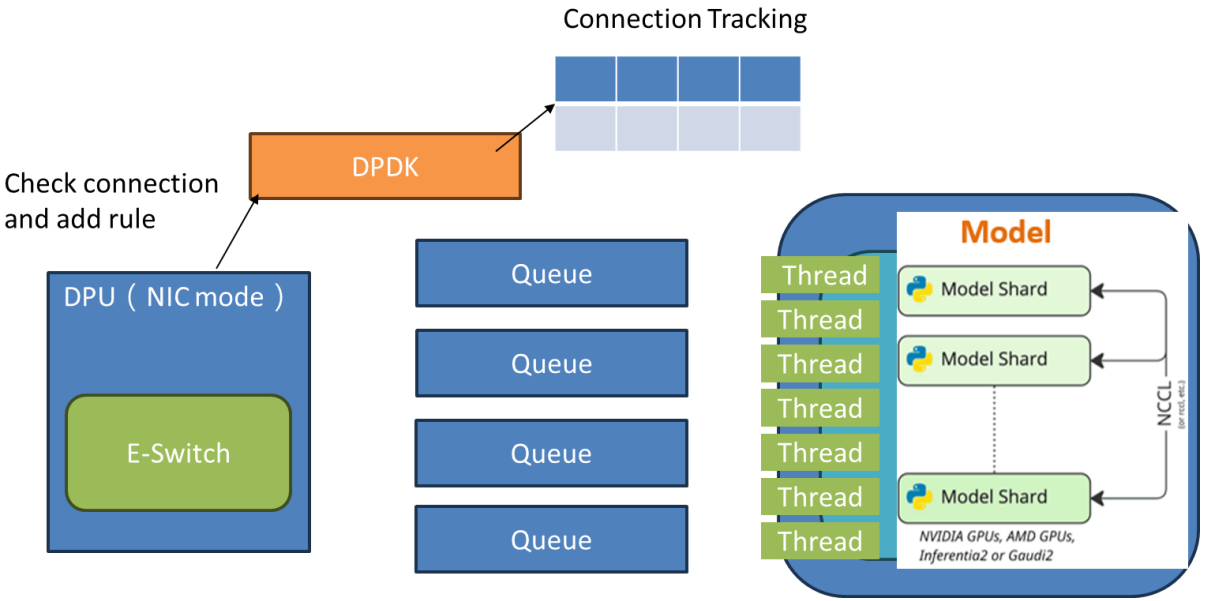
Easy, DPU handles everything ?



DPU gives you only the possibility.

The devil is in the experiments again.

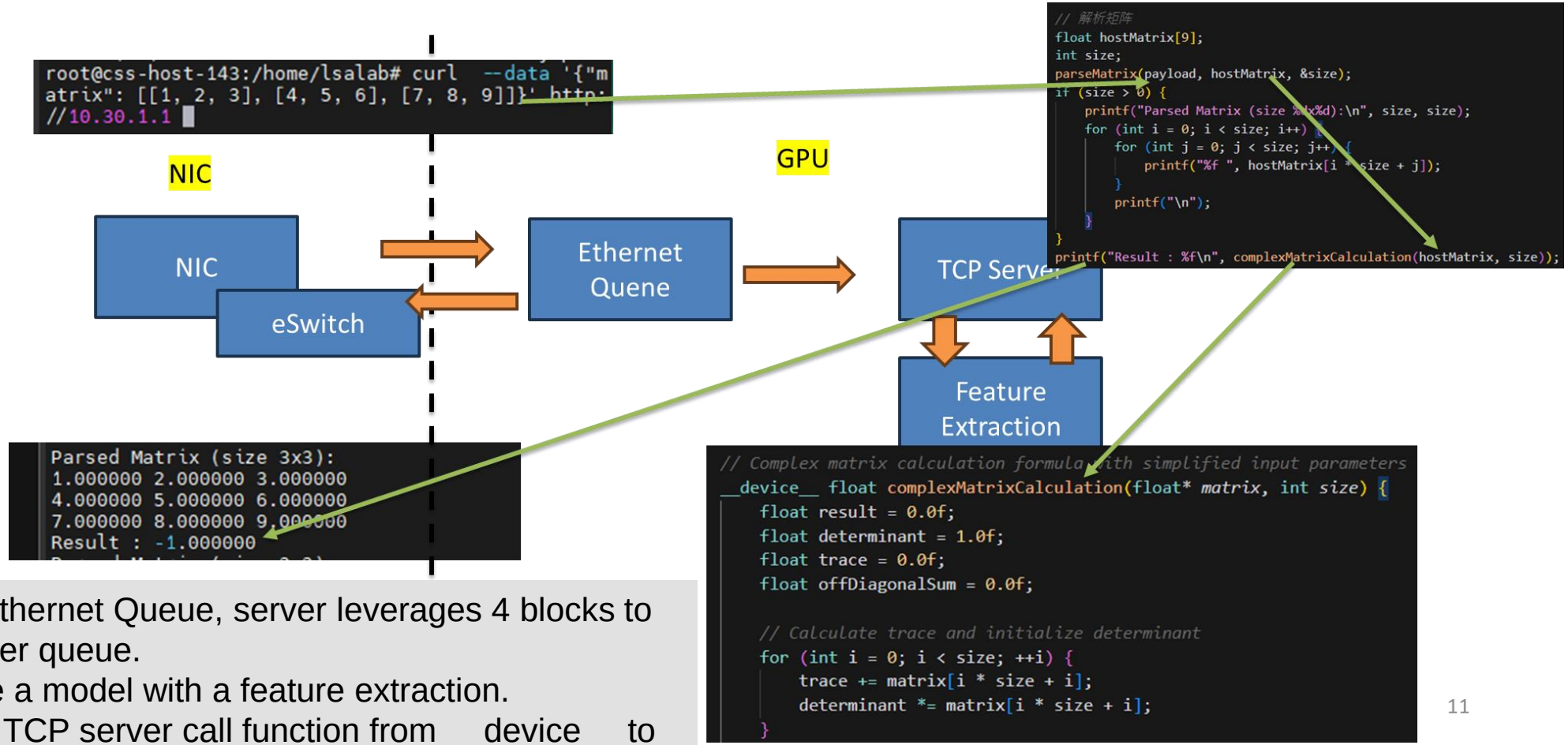
How did this strategy change?



1. Make GPU receive TCP/UDP based packets.
2. Conduct a model function on GPU
3. Transfer the TCP payload to the GPU and measure its processing efficiency

Build from Scratch

What were you able to accomplish?

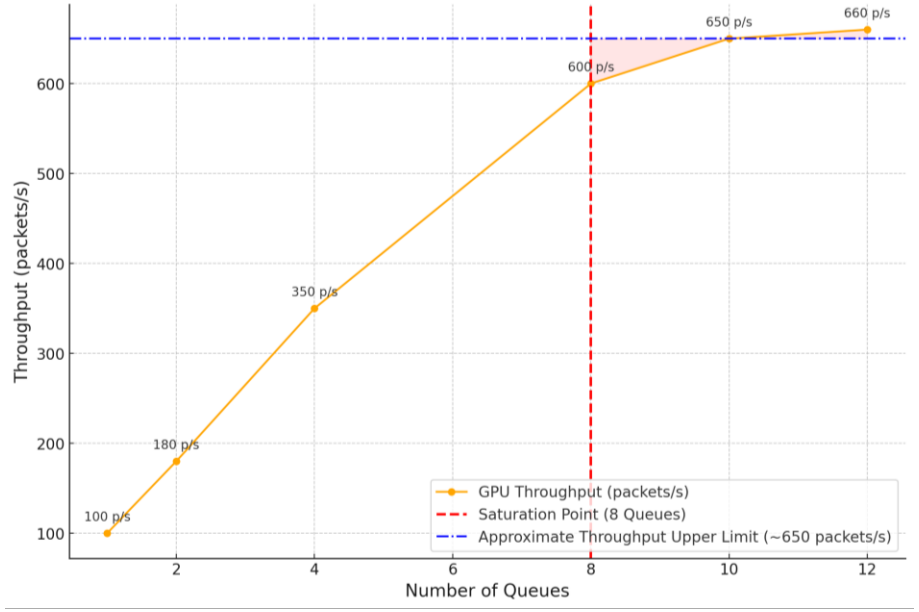


- For each Ethernet Queue, server leverages 4 blocks to consume per queue.
- We replace a model with a feature extraction.
- On CUDA, TCP server call function from __device__ to __device without Dynamic Parallelism

Accelerated Results

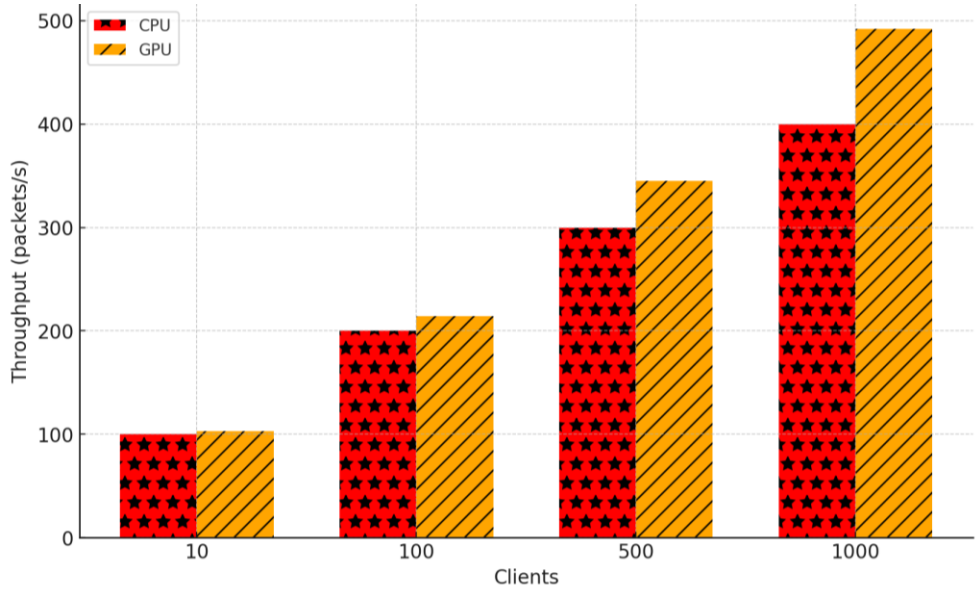
Did you achieve a speed up?

GPU Packets processing ability



GPUNetIO reaches the highest throughput with 8 packets. (no optimization)

Packet Processing Results

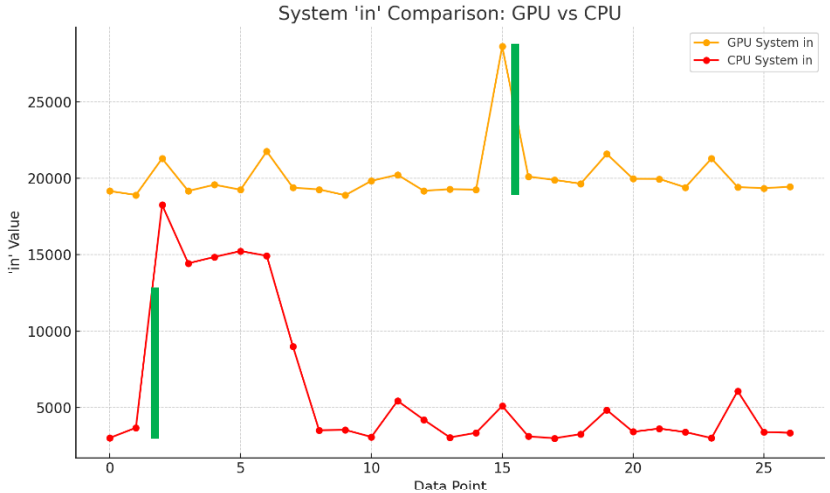


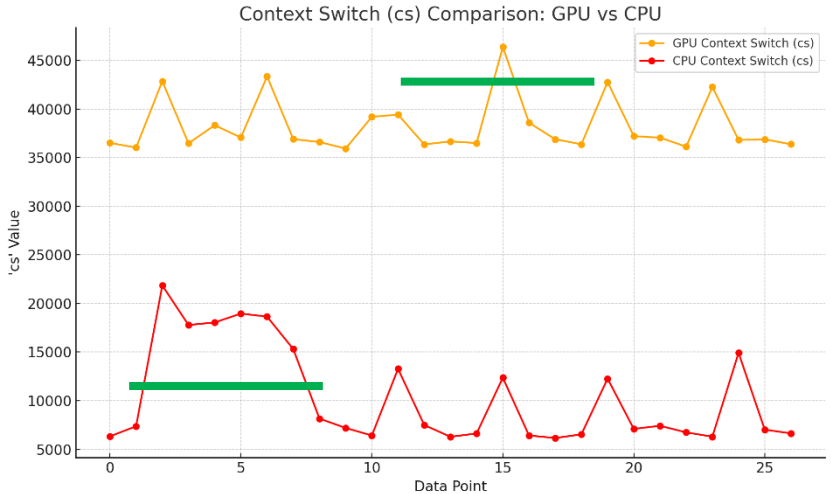
With 4 queues, speed up to ~23%

Accelerated Results

Did you achieve new scientific goals?

CPU Usage（from interrupt rate）





- GPUNetIO triggers interrupts during the middle of the processing flow, whereas the CPU triggers them at the beginning.
- GPUNetIO-based packet processing occupies a CPU core for DPDK, which seems to consume more resources.
- However, we can clearly observe that the throughput is lower compared to CPU-based packet processing.
- The context switch rate also observed higher CPU, in our estimation, we save 110w generally.

Conclusion

- Due to environmental factors, this experiment primarily used DPU BlueField-2 and DOCA 2.5. However, BlueField-3 is already available on the market, and GPU Direct transfer technology has become more mature and diverse.
- Although there are still some overheads in the Hackathon results, it is undoubtedly an architecture worth focusing on in the foreseeable future.
- Shout out to Kevin and Sungta for their amazing support and guidance!
- Thank you to Nvidia for providing this opportunity to communicate and discuss with frontline professionals.


Thank You
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