Day 3 – Final Presentation

NARLabs 國家實驗研究院
國家高速網路與計算中心
National Center for High-performance Computing

Team3: NTHU-LSAlab

OPEN HACKATHONS
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Kick-off Meeting (Nov 16) Virtual	● 02:00PM - 02:05PM: Welcome and event overview (Jay, CK) ● 02:05PM – 02:10PM: NCHC opening (王順泰組長@NCHC) ● 02:10PM – 02:15PM: Hackathon team opening (Bharat) ● 02:15PM - 03:00PM: Round table self-introduction (Team & Mentor). ● 3 mins for each team lead ● 1 mins for two mentors per team ● 03:00PM - 03:05PM: 5 mins break ● 03:05PM - 03:15PM: Introduction to computing resources (Kuan-Ting) ● 03:15PM - 04:00PM: Introduction to Nsight Analysis Tools (Leo Chen) ● 04:00PM - 04:30PM: breakout rooms (Team & Mentor)
Day 1 (November 23) Virtual	● 02:00PM - 03:00PM: Scrum #1 (5 mins presentation per team)
Day 2 (November 30) Virtual	● 02:00PM - 03:00PM: Scrum #2 (5 mins presentation per team)
Day 3 (August 24) In-Person	● 10:00 AM - 10:30 PM: Welcome and event description ● 10:30 AM - 12:00 PM: Final presentation (12 mins presentation +3 minutes QA per team) ● 12:00 PM - 01:30 PM: Lunch time ● 01:30 PM - 03:00 PM: Final presentation (12 mins presentation +3 minutes QA per team) ● 03:00 PM - 04:00 PM: Wrap-up session

Total presentation time is 12 minutes + 3 minutes QA

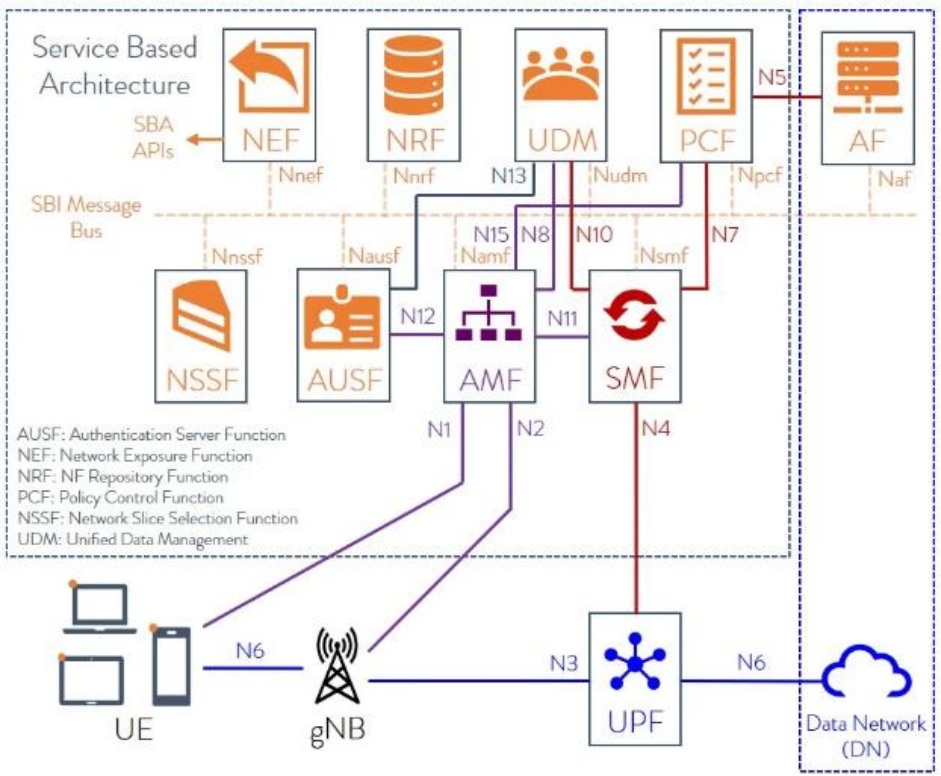
Team 3: NTHU-LSALAB

Team Members：
Aiden Huang (Speaker), Ivan Ou, Samuel Ke

Mentors (Name, organization, picture)
Sungta Tsai, Nvidia
Erez Ferber, Nvidia

5G SBA (Service Based Architecture)

- Service-Based Architectures provide a modular framework from which common applications can be deployed using components from various sources and suppliers.
- The 3GPP defines a **Service-Based Architecture (SBA)** in which the control plane functionality and common data repositories of a 5G network are delivered through a set of interconnected **Network Functions (NFs),** with each NF authorized to access the services of other NFs.



- Assuming the role of either service consumer or service producer, Network Functions are self-contained, independent, and reusable.
- Each Network Function service exposes its functionality through a Service-Based Interface (SBI), which employs a well-defined REST interface using HTTP/2.
- To mitigate issues around TCP head-of-line (HOL) blocking, the Quick UDP Internet Connections (QUIC) protocol may be used in the future.

Source：https://techcommunity.microsoft.com/t5/azure-for-operators-blog/what-is-the-5g-service-based-architecture-sba/ba-p/3831367

Kubernetes and 5G SBA

From ERICSSON Aspect :

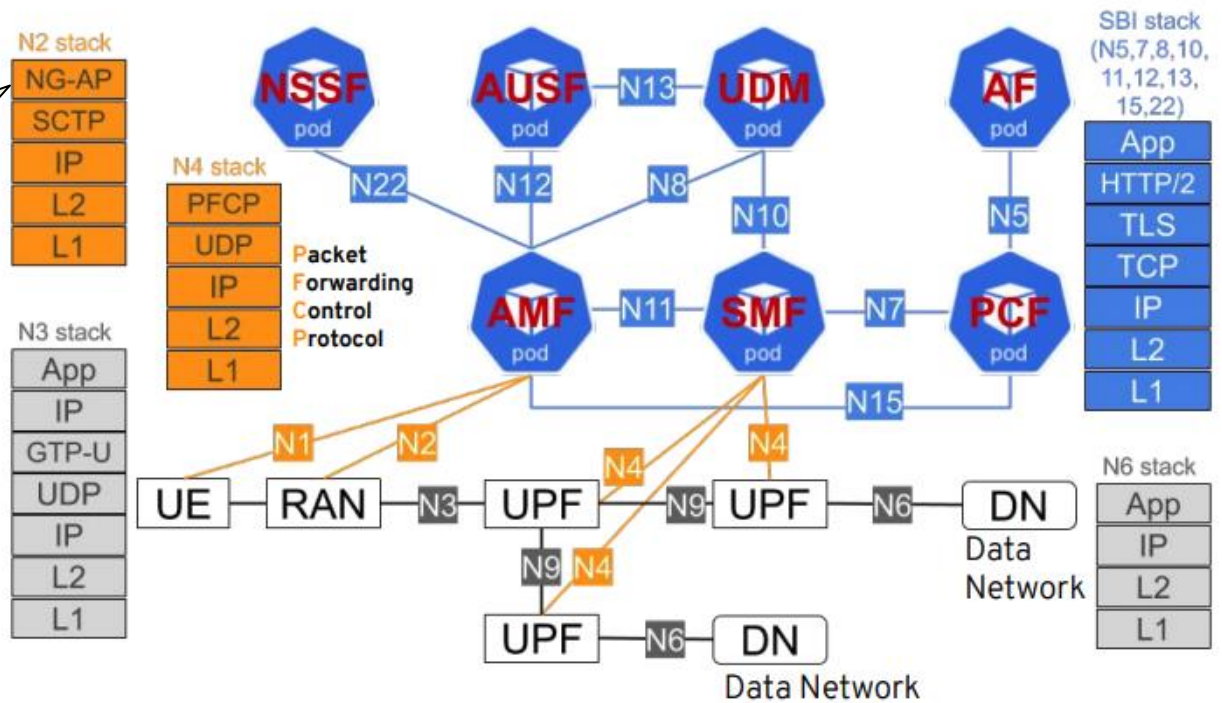
Source：https://www.ericsson.com/en/blog/2020/3/benefits-of-kubernetes-on-bare-metal-cloud-infrastructure

- The telecom industry is now moving on with this technology due to several benefits of using Kubernetes over bare metal infrastructure compared to virtualized infrastructure.

The SBA architecture adopts the existing TCP/IP network structure, greatly enhancing compatibility and portability.

Therefore, managing SBA components can be easily done using common container management platforms, with Kubernetes being the most prevalent.

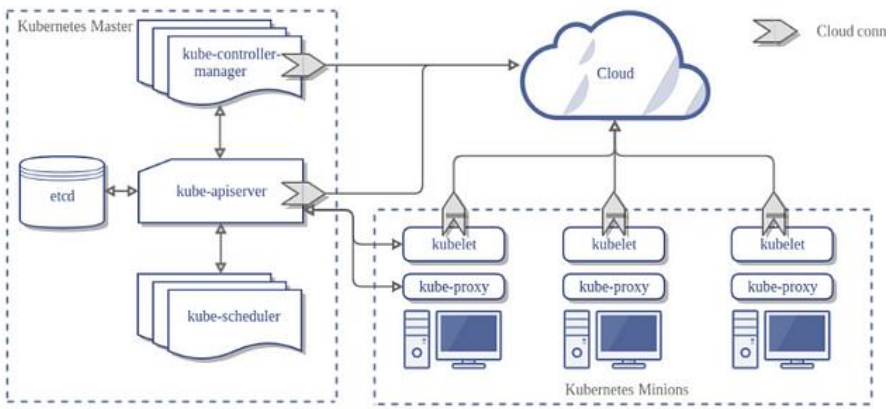
While Kubernetes can be retained, in pursuit of compatibility, it also inherits issues related to computational efficiency and latency.



Source：https://events19.linuxfoundation.org/wp-content/uploads/2019/07/OSS2019-HS-k8sNativeInfra-OperatorFor5Gedge.pdf

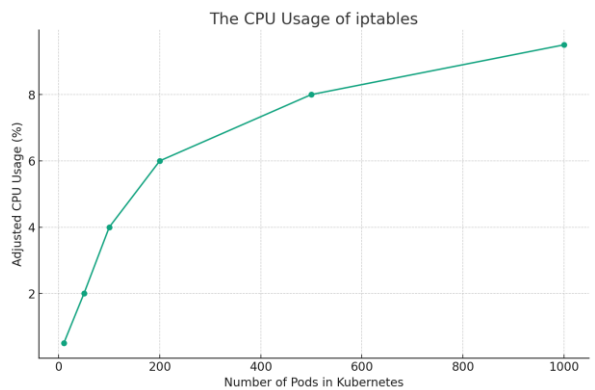
Kubernetes Network Implement and Issues

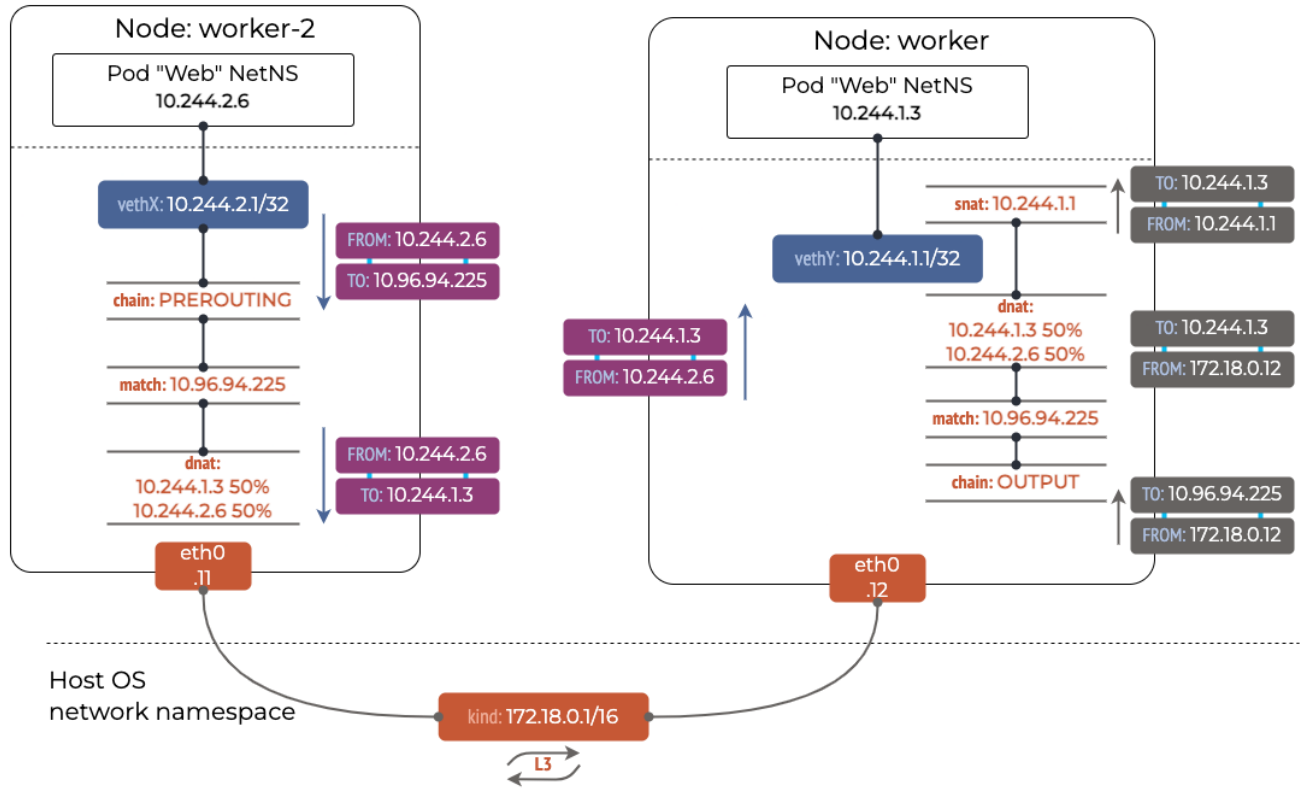
Kubernetes Architecture



iptable consumes host CPU resources

```
$ kubectl get daemonset -n kube-system -l k8s-app=kube-proxy
NAME         DESIRED   CURRENT   READY   UP-TO-DATE   AVAILABLE   NODE SELECTOR            AGE
kube-proxy   3         3         3       3            3           kubernetes.io/os=linux   2d16h
```





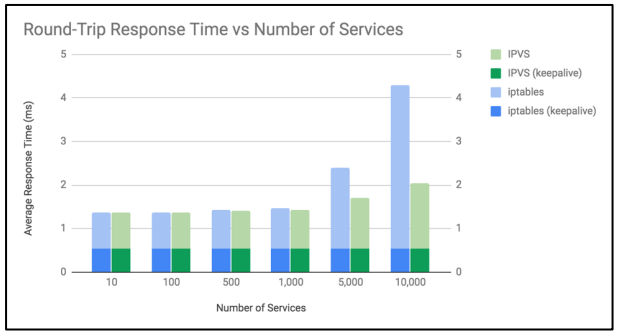
1.Pod-to-Service communication (purple packets) – implemented entirely within an egress node and relies on CNI for pod-to-pod reachability.

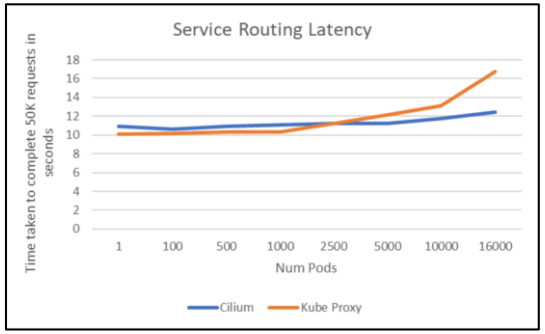
2.Any-to-Service communication (grey packets) – includes any externally-originated and, most notable, node-to-service traffic flows, which also serve as a loading balancer.

Approach

Many solutions are enhancing the network processing efficiency of Kubernetes.

- ipvs：https://kubernetes.io/docs/reference/networking/virtual-ips/
- Cilium：https://docs.cilium.io/en/stable/network/kubernetes/kubeproxy-free/

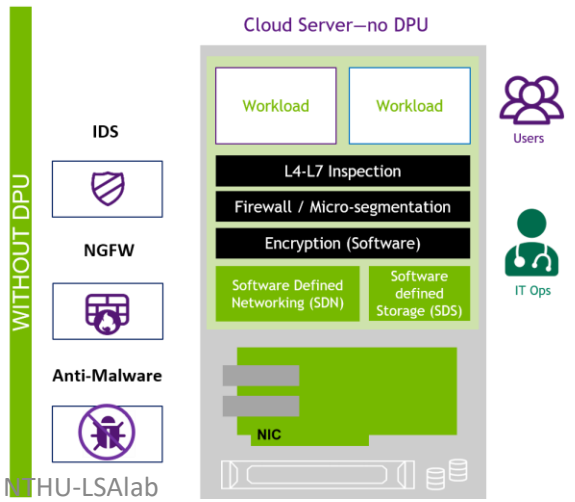


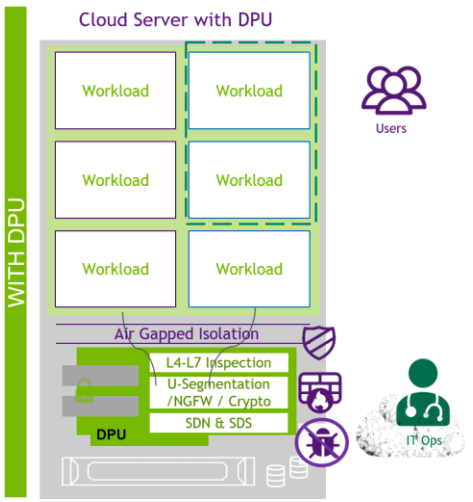


However, whether using IPVS as a high-performance network module or utilizing Cilium with a new network kernel stack, both approaches consume host CPU resources, thus adding to the overall cost of running the CNF.

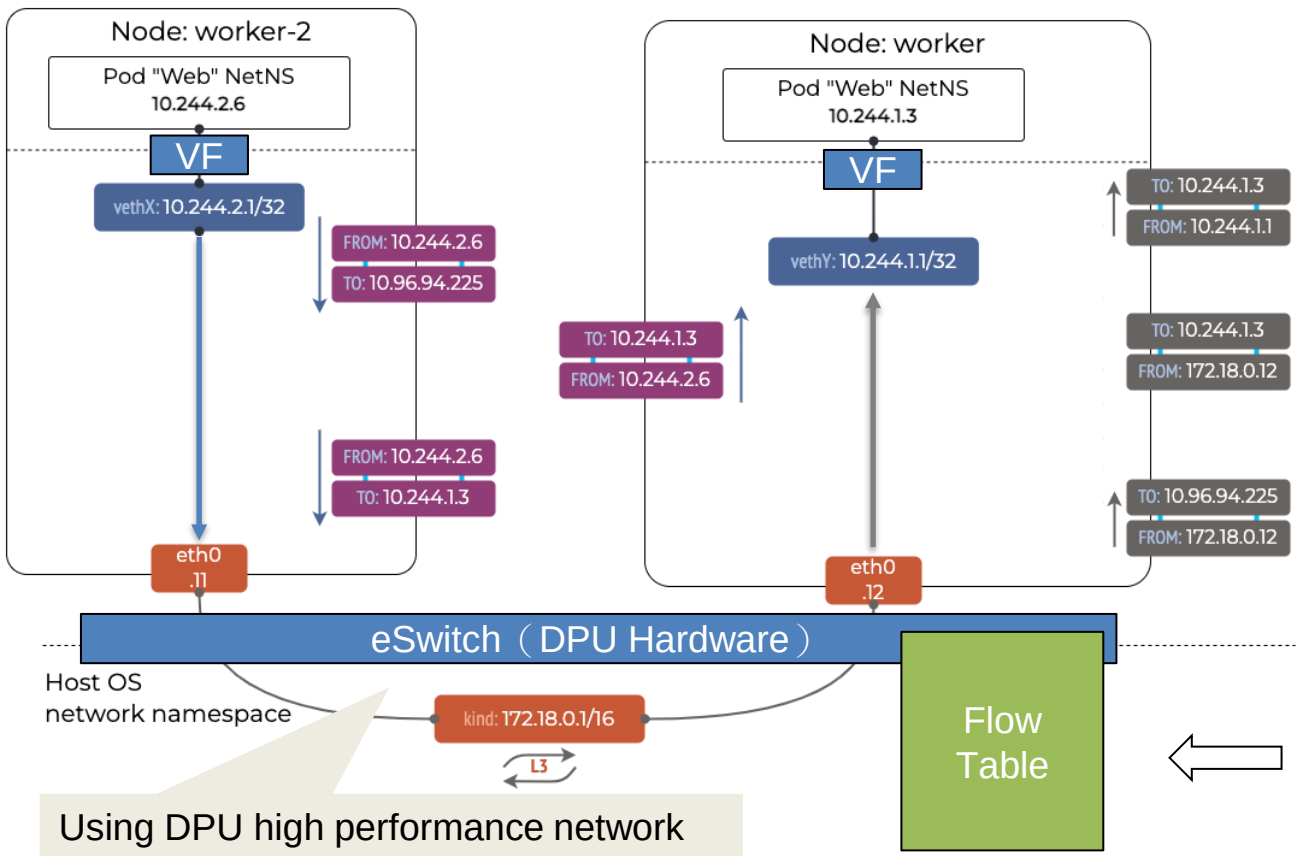
We need highly efficient and low-cost solution!!

NVIDIA BlueField-2/3 DPU（Data Process Unit）combines the ConnectX®-6 Dx with programmable Arm® cores and hardware offloads for software-defined storage, networking, security, and management workloads.

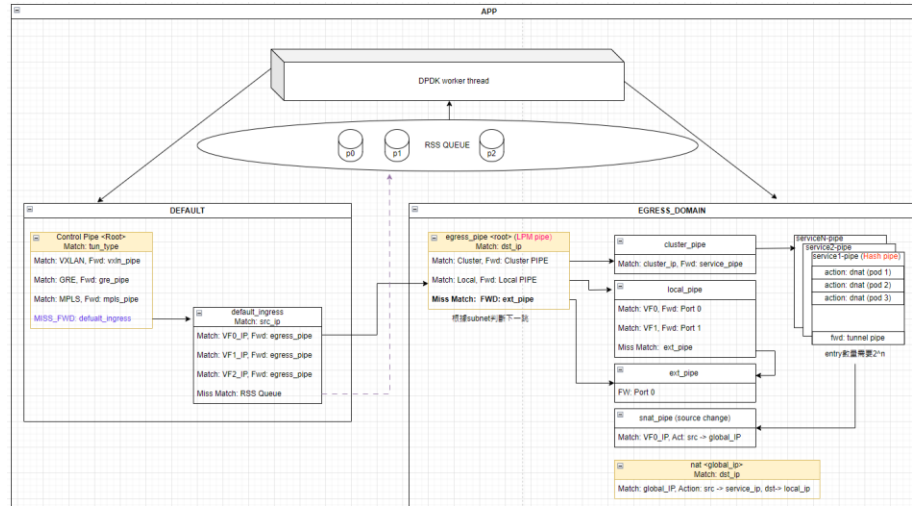


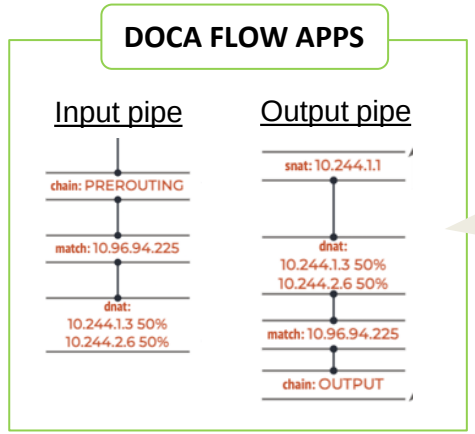


Kubernetes Network Offload Architecture



Using DPU high performance network infrastructure instead of TUN/TAP





Reimplement network stack by DOCA flow

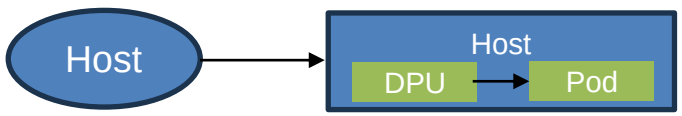
Experiment Results

Expectation

- The newly established network stack is capable of handling the same network traffic.
- It reduces host CPU usage by offloading network processing to the network card.

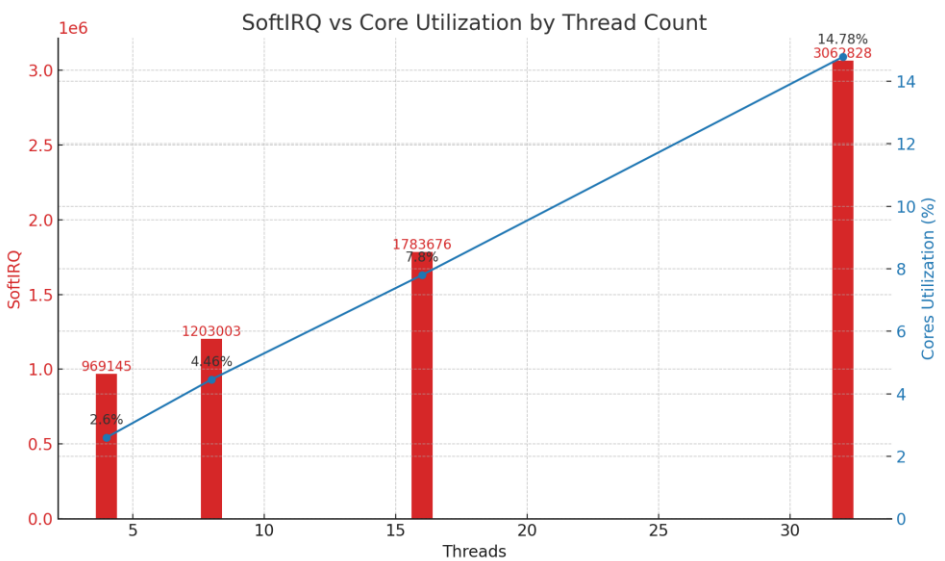
Results

1. The newly established network stack is capable of handling the same amount of network traffic.




```
[SUM]  0.00-10.00 sec  115 GBytes  99.0 Gbits/sec 1109     sender
[SUM]  0.00-10.00 sec  115 GBytes  98.9 Gbits/sec          receiver
```

2. It reduces host CPU usage by offloading the network processing to the network card.



Core Usage	Power Usage (W)	Request/sec
6.8	37.00	680.0
11.7	59.25	1170.0
18.9	77.25	1890.0
37.1	132.75	3710.0

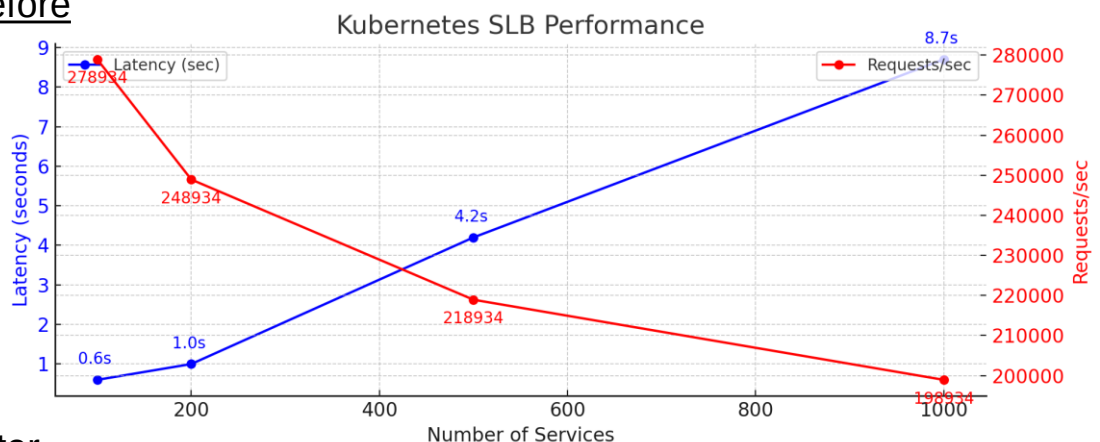
Formula Source：https://dcmag.fr/wp-content/uploads/2022/11/nvidia-dpu-power-efficiency-white-paper-2508650.pdf

Experiment Results(cont'd)

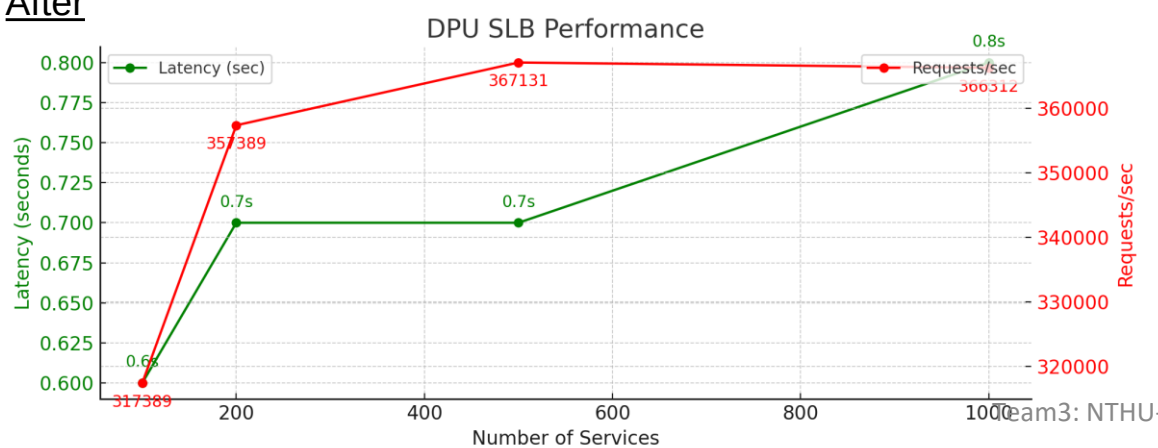
Results

3. Additionally, it was discovered that this reduces the latency issues associated with iptables-based SLBs.

Before



After



- The chart shows that using Kubernetes as an SLB, the capacity to handle services decreases as more 5G services are activated.
- Additionally, the increasing number of Chains in iptables for services impacts the response capability.
- After switching to DPU, where the SLB becomes Rule-Based and distributes tasks via client port hashing done in hardware, there is barely no latency.

  Latency is a key performance indicator in 5G that significantly impacts the effectiveness of Service-Based Architecture (SBA). 1 2 3
- Ultimately, this allows the host to reach its maximum capacity for handling 5G components, and the overall processing capability is higher compared to using Kubernetes SLB.

Experience

Analysis

- Utilizing the natively provided high-efficiency SR-IOV network architecture to increase the network speed of 5G Service.
- Preserving a significant amount of CPU processing resources for 5G SBA components.

Challenge

- Reconstructing network architecture presents significant challenges. The DOCA Flow Framework, integrating with the DPDK Framework, requires developers to have experience in both, which comparatively increases the challenge.
- While DPUs offer numerous acceleration features, effectively utilizing multiple functions simultaneously demands additional consideration in data communication.
- Documentation and sample codes are sometimes not as intuitive as needed.
  - Thanks a lot for the guidance from both mentors.

Future plans and Wishlisyt

- In practical SBA applications, packet inspection features are added to analyze packet security and detect user behavior.
- Our initial design intended to use GPUs for packet analysis, but due to scheduling issues, it was not completed. We look forward to its implementation in the future.
  - **For those who may use it in the future**: a single DOCA Flow Pipe cannot trigger transmission and forwarding simultaneously, but you can transfer packets to a port and then mirror them to the other ports.

- DOCA Flow is the foundational infrastructure for many DPU features, and we hope to provide more lab exercises.

Thanks for your listening.

Any Question and Feedback?