

A close-up, low-angle shot of a golden wheat field under bright, warm sunlight. The wheat stalks are in sharp focus in the foreground, with a soft bokeh effect in the background. The overall color palette is warm, dominated by yellows and oranges.

QLF NETWORKING

LFN Developer & Testing Forum

OLF NETWORKING

LFN Developer & Testing Forum

L3aF Integration with 5G – User Plane Function





NGKORE



L3AF

OLF
NETWORKING

LFN Developer & Testing Forum

Who we are?



Kupen Stack





NGKORE

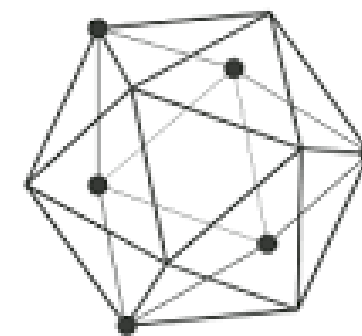


L3AF

OLF
NETWORKING

LFN Developer & Testing Forum

Our collaboration:



HYPERLEDGER
FOUNDATION



NGKORE



L3AF

OLF
NETWORKING

LFN Developer & Testing Forum

User Plane Function ?

- Perform packet forwarding and forwarding policy enforcement for user data traffic.
- Ensures that data packets are delivered to the appropriate destinations based on the defined network policies and quality of service (QoS) requirements.
- The UPF also supports various functions related to traffic management, such as packet inspection, filtering, and deep packet inspection (DPI).
- Also enables some advanced 5G features, including network slicing.



NGKORE



L3AF

OLF
NETWORKING

LFN Developer & Testing Forum

UPF Architecture:

The UPF implementation consists of two layers:

- PFCP Agent (pfcpiface): a Go-based implementation of the PFCP northbound API used to interact with the mobile core control plane.
- Datapath: responsible for the actual data plane packet processing.



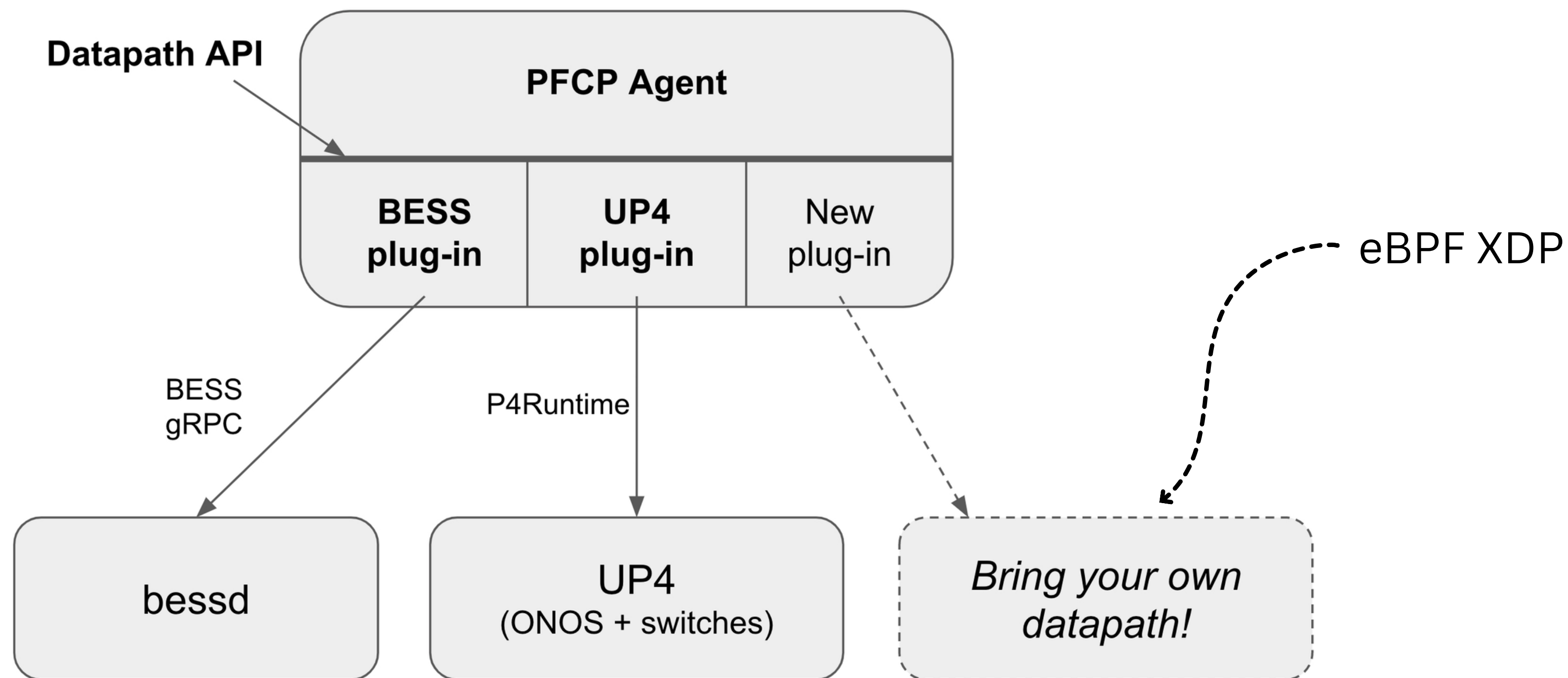
NGKORE



L3AF

OLF
NETWORKING

LFN Developer & Testing Forum





NGKORE

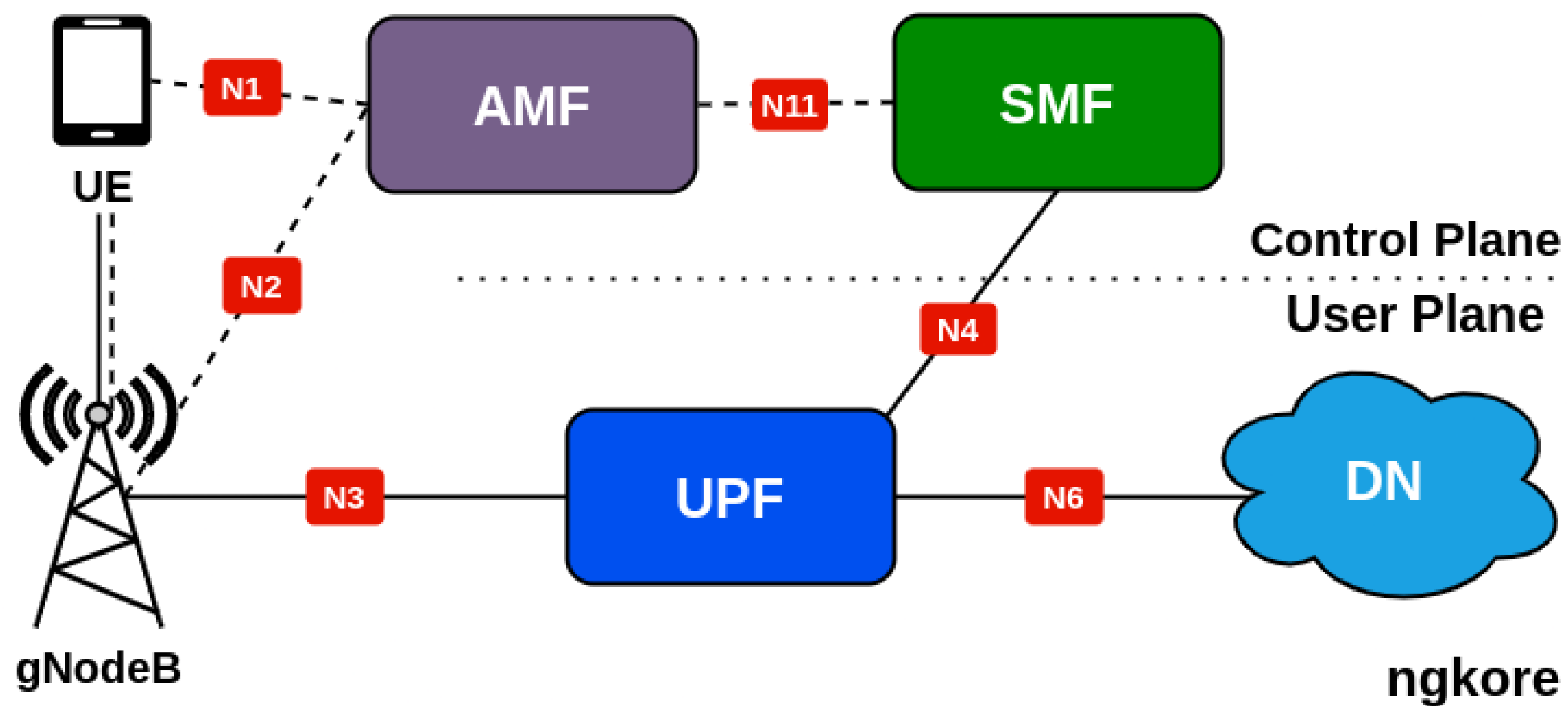


L3AF

DLF
NETWORKING

LFN Developer & Testing Forum

UPF in 5G-Architecture





NGKORE

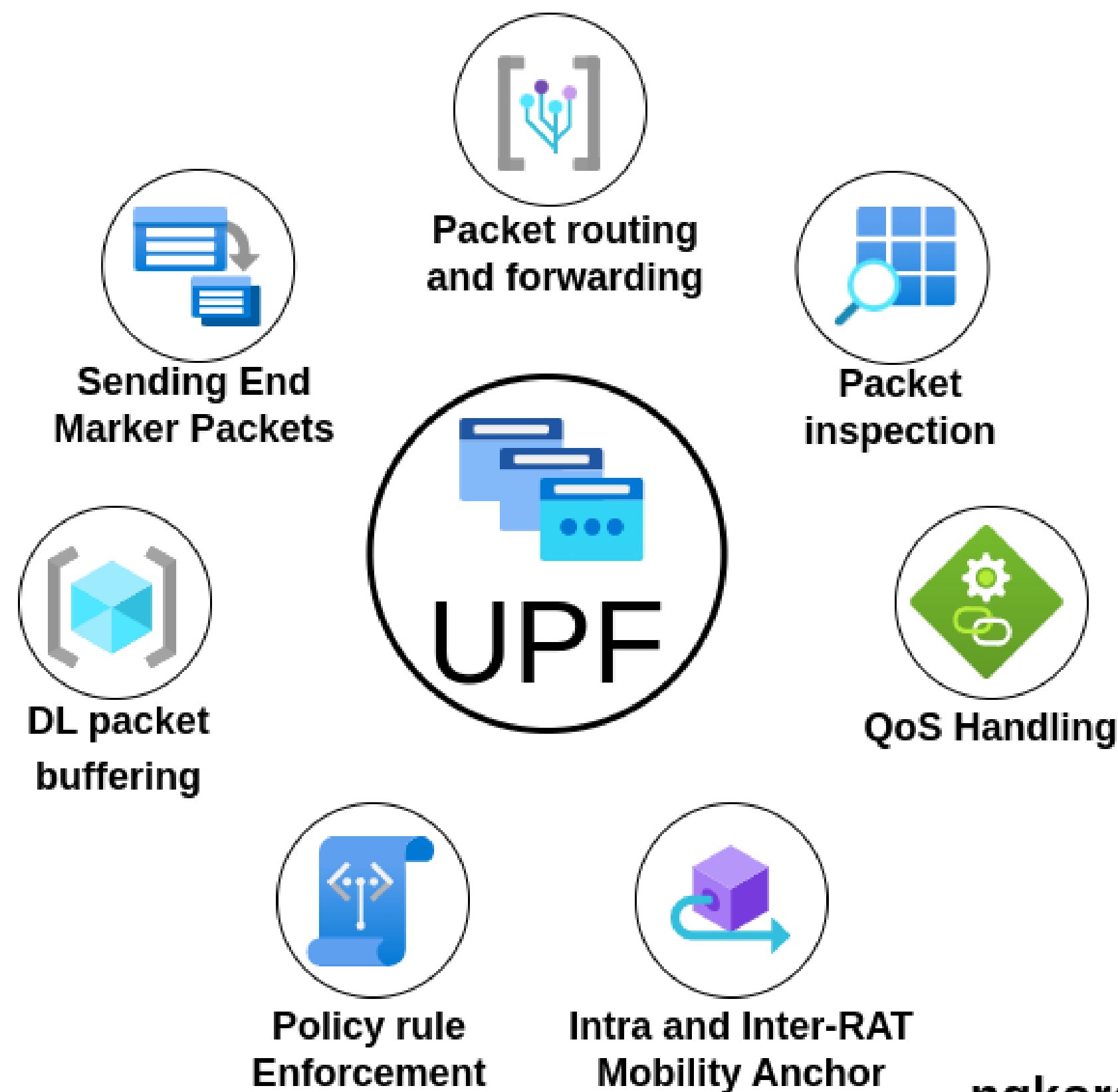


L3AF

DLF
NETWORKING

LFN Developer & Testing Forum

The Versatility of UPF:



ngkore



NGKORE



L3AF

OLF
NETWORKING

LFN Developer & Testing Forum

Our old Friend: DPDK

Using DPDK to accelerate packet processing in UPF:

- Only specific NICs are supported. i.e H/W dependency
- PMD keeps NIC usage all-time high.
- Integration with non-DPDK apps is a bit challenging.



NGKORE



L3AF

OLF
NETWORKING

LFN Developer & Testing Forum

eXpress Data Path

- In-kernel fast path. Not bypass.
- Does not req dedicating full CPU cores to Packet processing (unlike DPDK).
- More compatible with NICs, but with comparatively less performance.
- Can be dynamically re-programmed without any service interruption.



NGKORE



L3AF

OLF
NETWORKING

LFN Developer & Testing Forum

eXpress Data Path

Some limitations:

- Limited program size.
- Managing multiple eBPF XDP progs can be a tough task, especially in Multi-node ecosystems.
- No way to monitor or see metrics of progs.
- No standard interface to control or integrate it with other sidecar applications.



NGKORE



L3AF

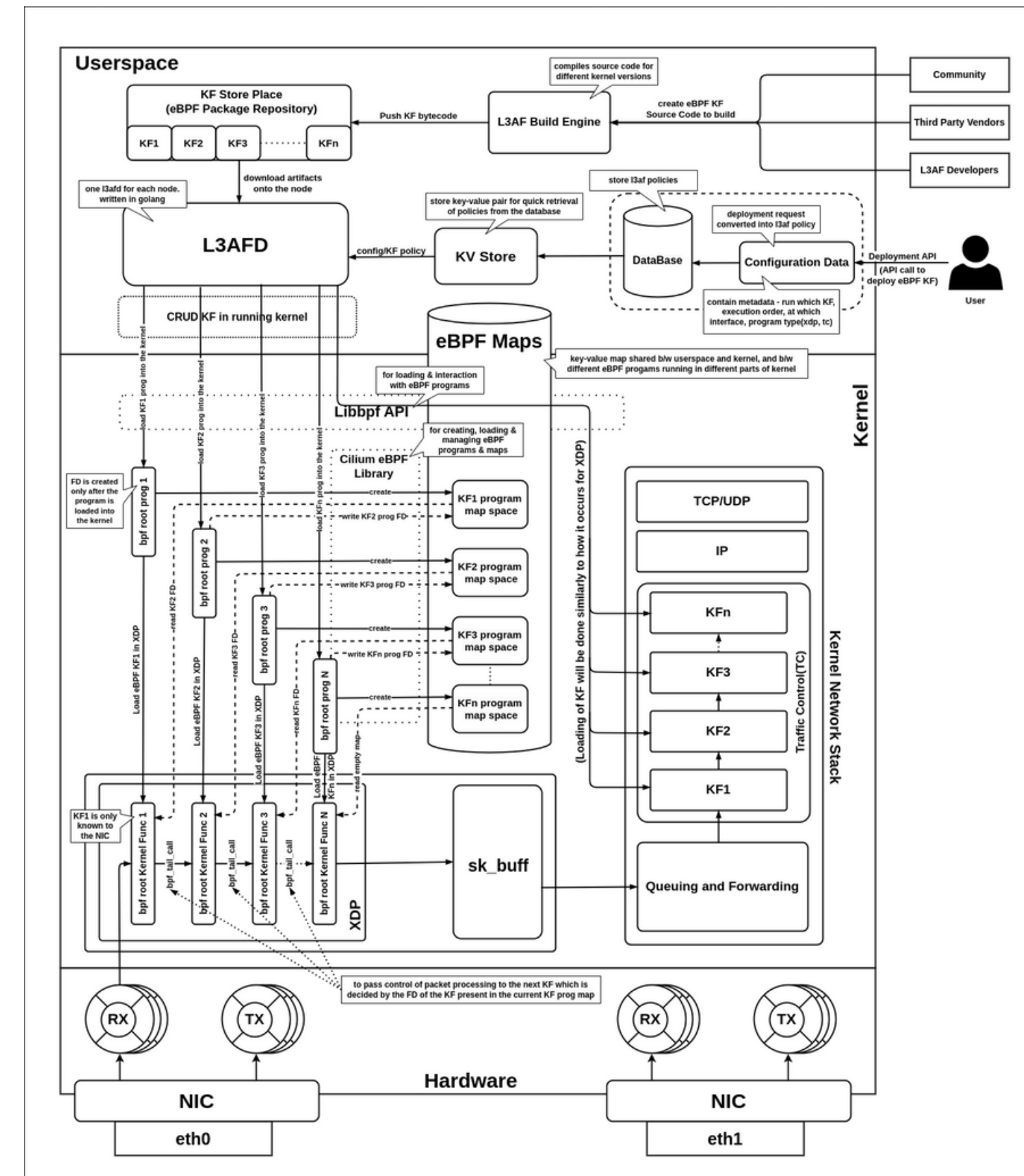
OLF
NETWORKING

LFN Developer & Testing Forum

L3AF comes into play

Complete lifecycle management of eBPF programs in the kernel

Architecture:





NGKORE



L3AF

OLF
NETWORKING

LFN Developer & Testing Forum

L3AF over XDP:

- It can orchestrate and manage multiple eBPF programs.
- Use PQL and Grafana to see metrics and monitoring of programs.
- Reads configuration data and manages the execution and monitoring of eBPF programs.
- Community-driven eBPF package marketplace where L3AF users can obtain a variety of eBPF programs developed by multiple sources.



NGKORE



L3AF

OLF
NETWORKING

LFN Developer & Testing Forum

UPF + L3AF:



NGKORE

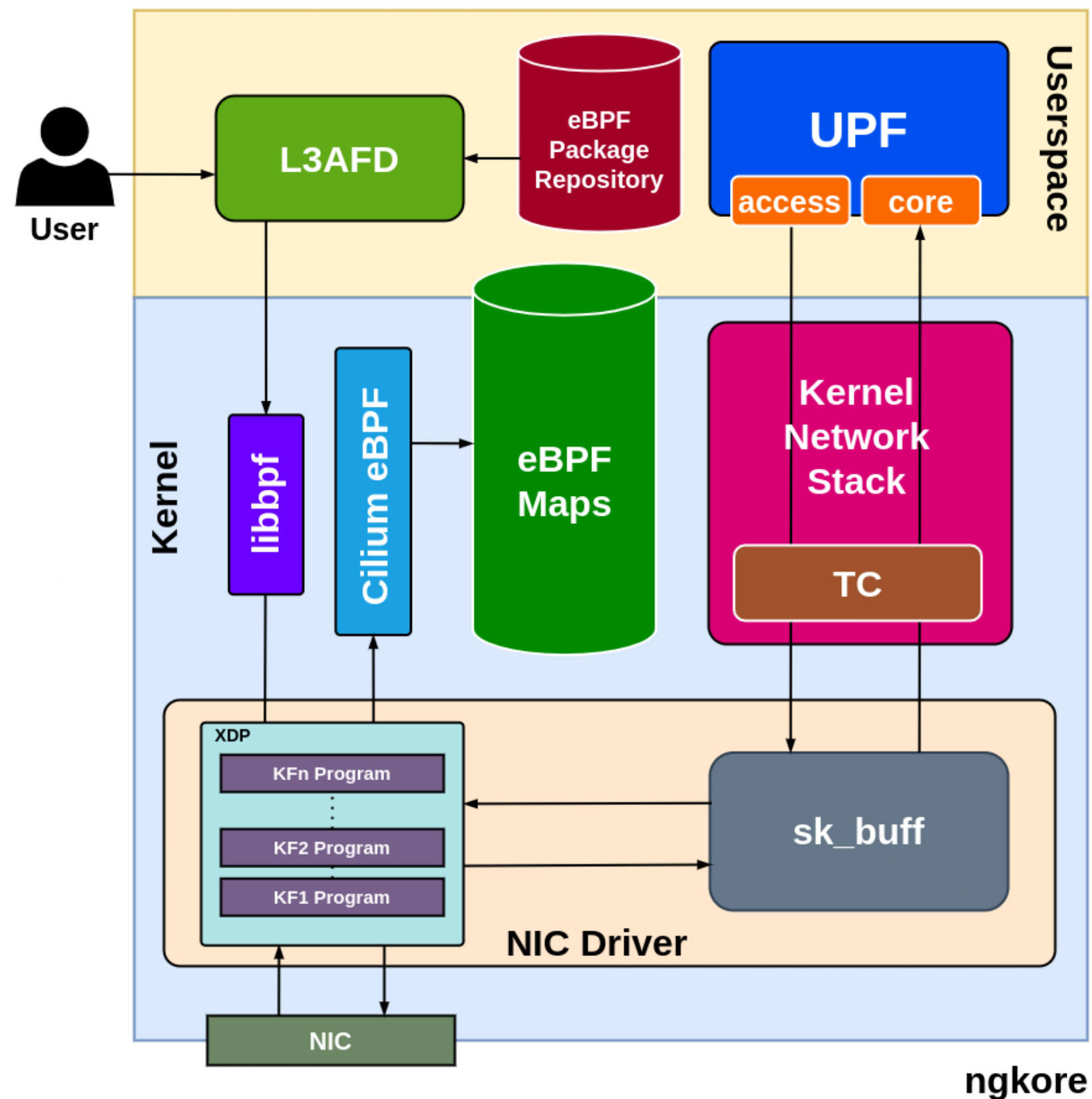


L3AF

OLF
NETWORKING

LFN Developer & Testing Forum

Without AFXDP





NGKORE

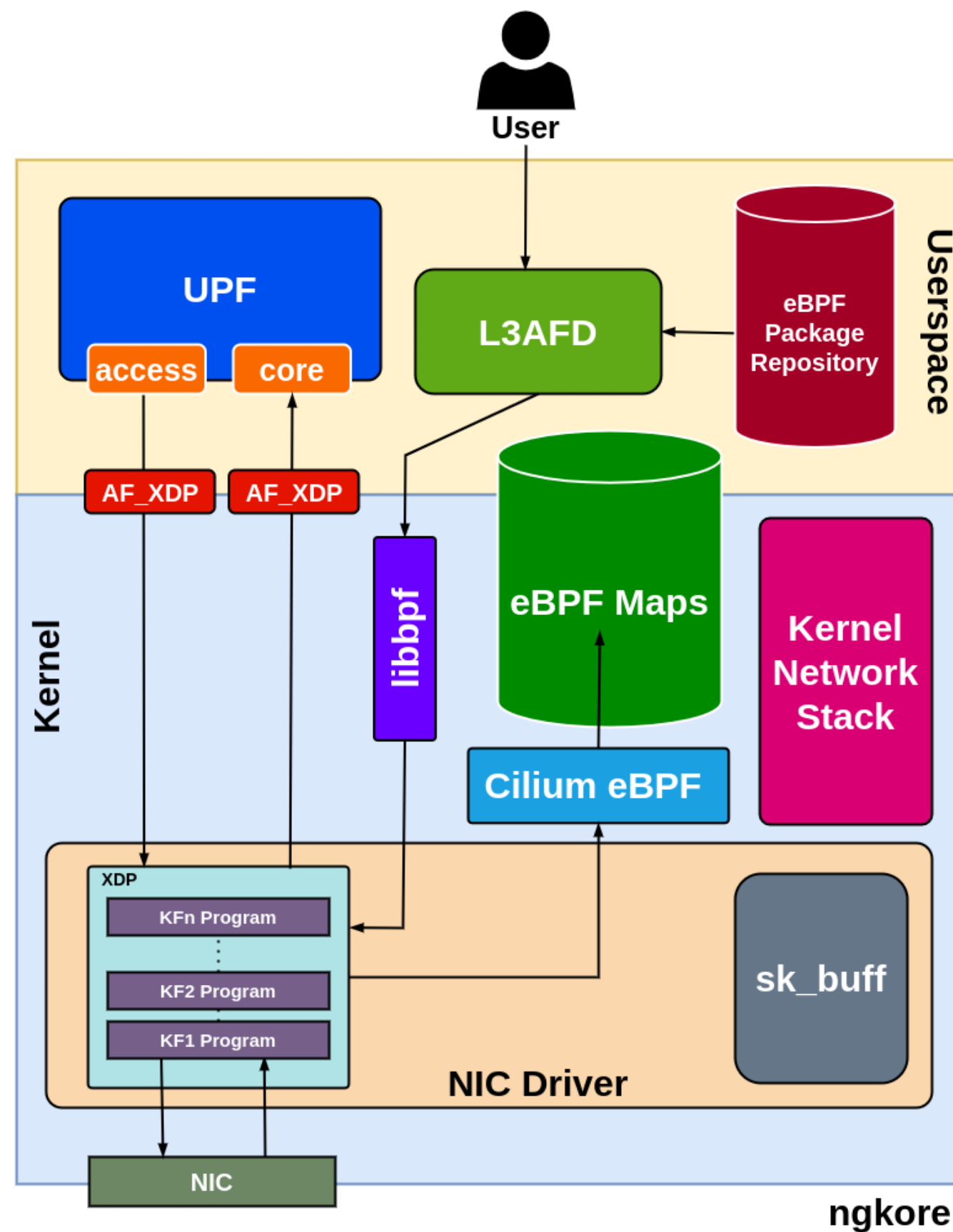


L3AF

OLF
NETWORKING

LFN Developer & Testing Forum

With AFXDP





NGKORE



L3AF

OLF
NETWORKING

LFN Developer & Testing Forum

Advantages:

We have ambitious future plans, including

- Faster and scalable dataplane using ebpf programs & L3af
- This integration will enable more advanced packet processing capabilities and further enhance the overall performance of L3af.
- Also, L3af aims to explore the potential of packet processing solely within the kernel using eBPF, offering improved efficiency and reduced overhead.



NGKORE



L3AF

OLF
NETWORKING

LFN Developer & Testing Forum

Future Plans with L3AF:

It enables developers to

- orchestrate multiple eBPF programs to enhance UPF functionality
- resulting in efficient packet processing and improved network performance.
- L3af provides horizontal and vertical scaling options
- allowing the deployment of multiple UPFs with multiple eBPF programs.



NGKORE



L3AF

OLF
NETWORKING

LFN Developer & Testing Forum

UPF LOGIC

- Complete UPF packet processing logic in kernel using eBPF programs
- Currently, we are undertaking significant strides in integrating AF_XDP sockets with the UPF and XDP.
- By doing so, we aim to extend the flexible, efficient management capabilities of the L3AF system to the modules currently under UPF



NGKORE



L3AF

OLF
NETWORKING

LFN Developer & Testing Forum

Overall, these developments signify a bold reimagining of our network architecture, leveraging cutting-edge technologies such as eBPF, AF_XDP, and L3AF for optimized network management. By continually striving to innovate, we aim to drive forward network efficiency, reduce latency, and provide robust and reliable network performance.



NGKORE



L3AF

OLF
NETWORKING

LFN Developer & Testing Forum

Horizontal and Vertical Scaling:



NGKORE



L3AF

OLF
NETWORKING

LFN Developer & Testing Forum

Horizontal Scaling

- Increase no. of UPFs
- L3AF can be a key component in managing horizontal scaling by coordinating the distribution and execution of eBPF programs across multiple UPF nodes.
- L3AF's ability to manage and monitor these programs can aid in load balancing, which is essential in effective horizontal scaling.



NGKORE



L3AF

OLF
NETWORKING

LFN Developer & Testing Forum

Vertical Scaling

- Increase capability of UPF
- Involves the addition of more resources to an existing node, such as more processing power or memory.
- The observability provided by eBPF and L3AF can be used to monitor the system's performance, helping to determine when vertical scaling might be necessary.



NGKORE



L3AF

OLF
NETWORKING

LFN Developer & Testing Forum

So points to note here



NGKORE

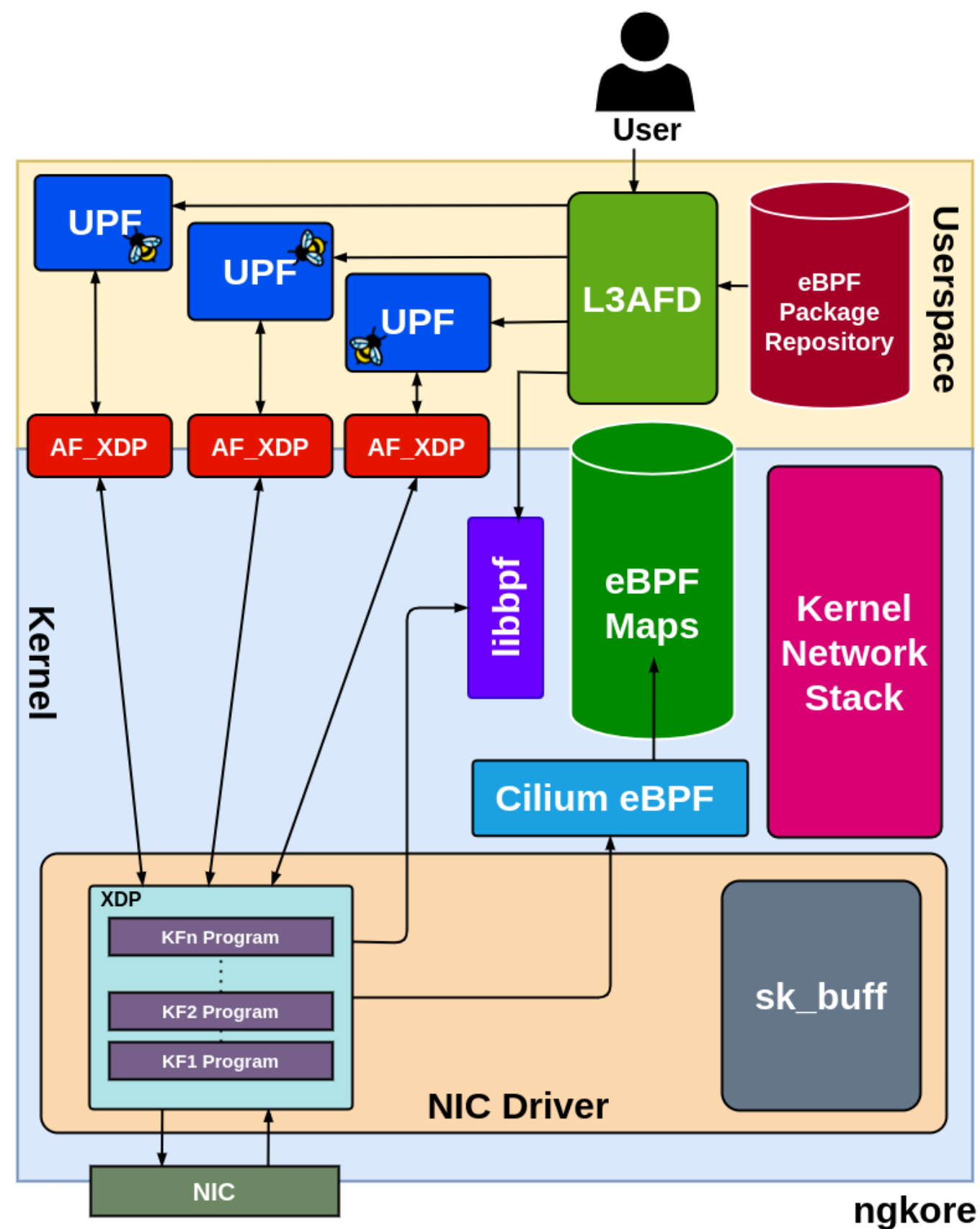


L3AF

OLF
NETWORKING

LFN Developer & Testing Forum

multiple UPF





NGKORE



L3AF

OLF
NETWORKING

LFN Developer & Testing Forum

What We've Achieved

- We have currently tested L3AF with our upf using the afxdp socket and importing all the ebpf programs at the xdp hookpoint and then bypassing the kernel network stack.
- We have also tried testing it with the UPF of sdcore and have got favorable results.
- Our team of researchers is busy writing upf related ebpf programs and some of which are being orchestrated by l3af and some of them are still in the process.
- We have tested with l3af's own ebpf package repository as well as our own ebpf programs.
- Our goal is to make fully scalable upf with fast packet processing technology using ebpf and l3af.
- We have already seen better performance after integrating ebpf and l3af. For now, we can't tell the exact benchmarking numbers but soon we will share that too.



NGKORE



L3AF

OLF
NETWORKING

LFN Developer & Testing Forum

References:

- An In-Kernel Solution Based on XDP for 5G UPF: Design, Prototype and Performance Evaluation- <https://ieeexplore.ieee.org/document/9615553>
- <https://github.com/navarrothiago/upf-bpf>
- <https://www.youtube.com/watch?v=vlrrrLtwEvU>



NGKORE



L3AF

OLF
NETWORKING

LFN Developer & Testing Forum

For any query:

Shankar: shankar.s@ramanujan.du.ac.in

The background of the entire image is a close-up, slightly blurred photograph of a golden wheat field. The wheat stalks are tall and thin, with their heads of grain clearly visible. The lighting is warm, suggesting a sunset or sunrise, with a soft orange and yellow glow. The text is overlaid on this background.

QLF NETWORKING

LFN Developer & Testing Forum