Solution Brief

5G Mobile Networks

# KDDI Builds Network Packet Broker to Ensure 5G Service Quality

## Mobile network operator's streamlined Network Packet Broker (NPB) cuts time to isolate, filter and analyze problem packets from four hours to 30 minutes


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To take its customer quality of service (QoS) and service level agreement (SLA) adherence capabilities to the next level in its 5G wireless network, leading Japanese communications service provider (CoSP) KDDI Corp. developed a high-performance network packet broker (NPB) to isolate, filter, and analyze data flows that are causing problems in the network.

The goal of the project was to reduce the manual troubleshooting process by using KDDI NPB software on a white box switch powered by the Intel® Tofino™ programmable Ethernet switch ASIC in order to improve resolution turnaround times and reduce troubleshooting costs. KDDI staff wrote the NPB software using P4 programming language and tested a proof-of-concept (PoC) of an NPB based on the Edgecore Networks Wedge100BF-32X programmable switch to address this challenge. The Edgecore Wedge100BF-32X is a P4-programmable switch based on the Intel Tofino series and Intel® Xeon® processor D-1500.

This solution has been validated on KDDI's testbed which measured a reduction in troubleshooting time from 4 hours to 30 minutes by moving from the previous manually dependent method to the NPB-automated approach.


## Challenge: A more cost-effective solution for network monitoring

An NPB is a specialized packet switch that collects traffic from network test access point (TAP) ports on switches across the network. The NPB filters and distributes each of the packet flows to network monitoring and performance management tools (see Figure 1).

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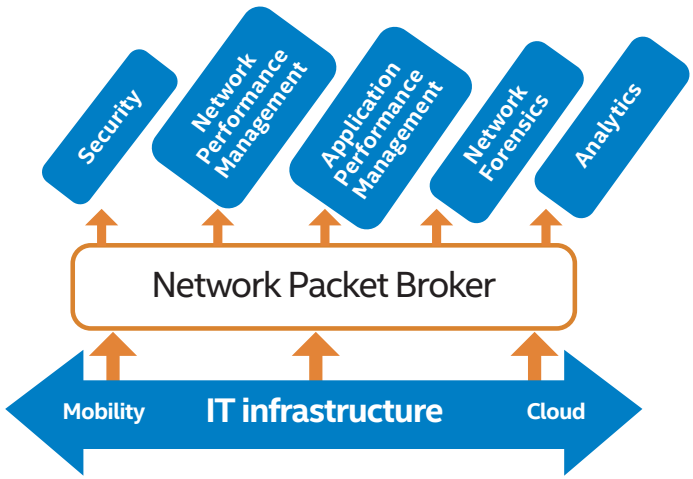


**Figure 1.** Network packet broker block diagram.

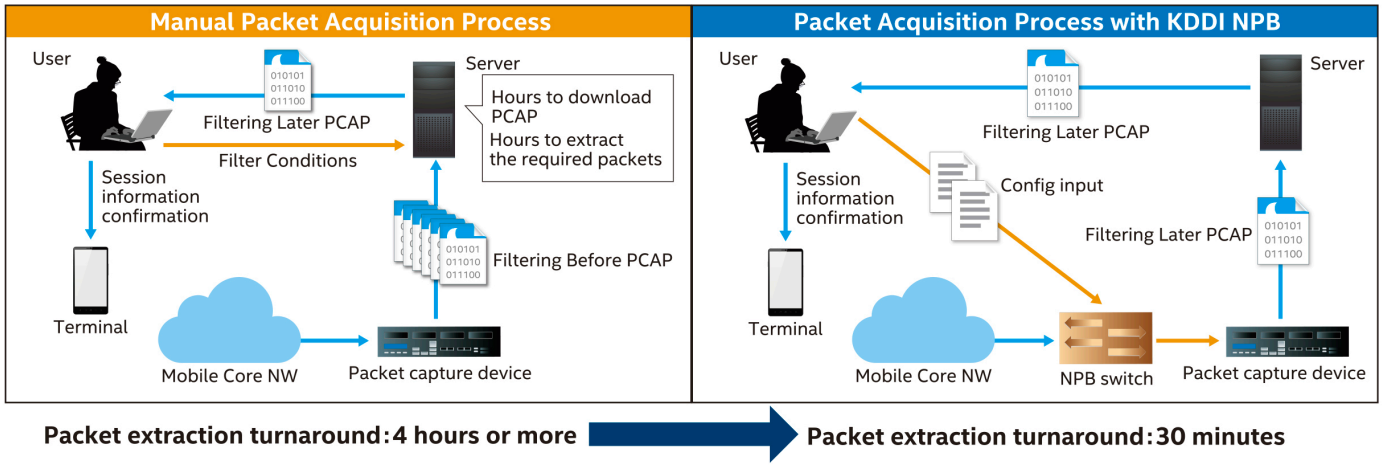


**Figure 2.** Comparison of manual packet isolation process and new network packet broker (NPB) high-performance packet isolation.

These tools can enable application analysis, network optimization and forensics, application performance management or network performance management. The NPB allows each network monitoring tool to extract a high proportion of the specific network traffic it needs from the total network traffic. By doing so, network packet brokers ensure improved effectiveness from network monitoring and security tools, to deliver improved performance across the network.

KDDI's NPB need was specific – it wanted to examine data flows from specific user-equipment (UE) devices solely to detect and isolate network performance issues and always with the permission of the UE owner.

Specific applications include:

- Investigating and detecting the cause for excessive packet loss
- Understanding the cause when network throughput is below specification
- Verifying IoT terminal performance in a real-world deployment
- Verifying the behavior of new Internet access protocols such as QUIC

In its evaluation of commercial NPBs, KDDI concluded that these brokers offered more features than the operator needed, and so built its own NPB that delivered more degrees of freedom in filtering operations and eliminated features KDDI didn't want to use.

The NPB was built for use with the operator's non-standalone 5G network, which offered 5G services using the 4G infrastructure and spectrum. KDDI is moving to a standalone 5G network over the next few years, to which the NPB system is expected to be applied also.

## Faster Time to Resolution

One of the reasons for developing the NPB is that the problem resolution process used (see Figure 2) in KDDI's 4G/LTE network took over four hours to isolate, filter and analyze the relevant traffic from all of the data flows on the network. This happened because the processing was executed offline and manual work was required.

The left side of Figure 2 shows how packet capture and analysis were implemented before the NPB. KDDI staff used a packet capture device to create a large-capacity PCAP file. This was transferred to a server, and required packets were filtered from the PCAP using session information as a search key. The right side of the image shows the process implemented with the NPB. The filtering condition configuration is set for the NPB by the management software. The NPB switch does all the filtering at wire speed and only the packets filtered by the P4 switch are recorded into a PCAP file for offline analysis.

Using the manual process, KDDI was not able to promptly respond to the troubleshooting and verification requests from other KDDI departments. With even more packets to examine in a higher-speed 5G network, the process had to change to deliver a faster response.

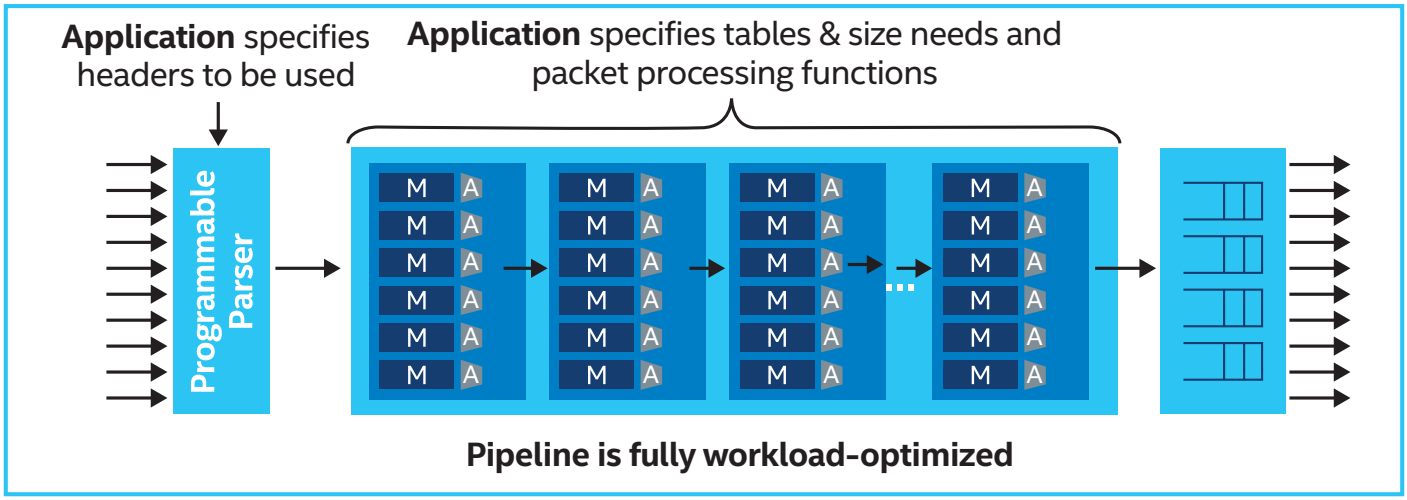


**Figure 3.** Block diagram of the match action pipeline in the Intel Tofino programmable Ethernet switch ASIC.

## NPB Utilizes P4-Programmable Switching

KDDI selected the Edgecore Wedge100BF-32X P4-programmable switch based on the Intel Tofino programmable Ethernet switch ASIC. The key criteria in this selection were high throughput of the switch and the data plane programmability that enabled the packet filtering and other NPB functionality to run in the switch.

The Edgecore Wedge100BF-32X is a bare-metal 1RU form-factor switch with a total of 32 QSFP28 ports, supporting 25/40/50/100 GbE connections. The switch also features an Intel Xeon Processor D-1500 for onboard compute.

The switch uses the Intel Tofino programmable Ethernet switch ASIC configured to provide up to 3.2 Tbps total throughput. The P4 programmability of the Intel Tofino switch is delivered using the switch ASIC's Protocol Independent Switch Architecture (PISA). PISA is based on a programmable packet parsing logic and match action forwarding engine that enables:

- Packet processing optimized to end-user applications
- Traffic filtering and aggregation from different TAPs
- Zero packet loss mechanism with line rate performance
- End-to-end network visibility
- Real-time visibility
- Adaptability to new workloads over time

Figure 3 shows how the switch parses the packets upon ingress for application specific headers, then uses the match action Pipeline architecture for application specific processing.

In addition, the device and abstraction APIs built into the Intel® P4 Studio Software Development Environment allowed KDDI developers to easily integrate their P4 applications with the local or remote control plane. These tools and APIs enabled KDDI to build highly differentiated fit-for-purpose NPB solutions.

The NPB also utilized an externally connected Linux server to run Ansible, an open source IT automation and configuration management tool that is used by KDDI to automate the port control of the NPB software on the Edgecore Wedge100BF-32X. Furthermore, a packet capture device is placed on the downstream side of the network. KDDI also benefitted from the open source community around P4 which provided information to help with the software development.

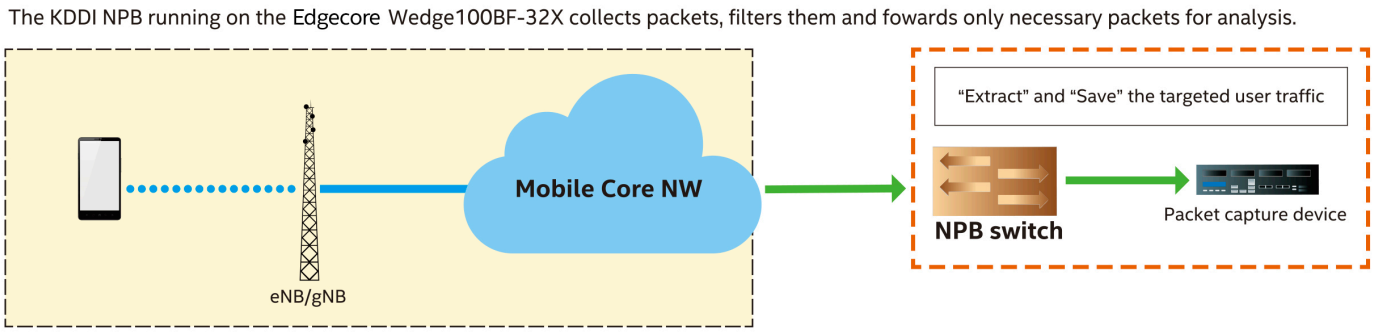


**Figure 4.** Network TAP ports are placed between the S1u and S11 port to collect packets for analysis.

## Isolating Network Trouble Spots

As shown in Figure 4, the TAP ports on the access switches copy and forward packets from the mobile network to an aggregation switch that is located at the S1u+S11 interface that connects the wireless network and the NPB network. The NPB switch is connected to this data flow and provides the isolation needed to filter the right packets and send them to the packet capture device.

More specifically, as shown in Figure 5, the control plane signaling messages are obtained by TAP ports near the S11 and are filtered by the Edgecore Wedge100BF-32X before they are then processed using Intel software on the switch's Linux-based Intel Xeon processor D-1500. The processed information is registered in the transfer table of the P4-programmable switch. In this way, only the data packets associated with the user (as identified by the user's session information or other methods) are filtered from the switch's user plane and captured by an external packet capture device.

Other processing, such as filtering only a specific value of a specific field in a packet, can also be performed in a P4-programmable switch at wire speed.

In addition, in order to reduce the traffic to the packet capture device, the payload of the IP packet can be removed as needed for analysis, leaving only the IP header. With this ingenuity, the traffic sent to the packet capture device is reduced dramatically.

With the Intel Tofino-based Edgecore Wedge100BF-32X switch, KDDI's NPB software's ability to define access control lists by user at wire speed in the network fabric is an important feature. KDDI also can use the match action Pipeline architecture of the Intel Tofino programmable switch ASIC to run multiple programs with multiple filtering conditions.

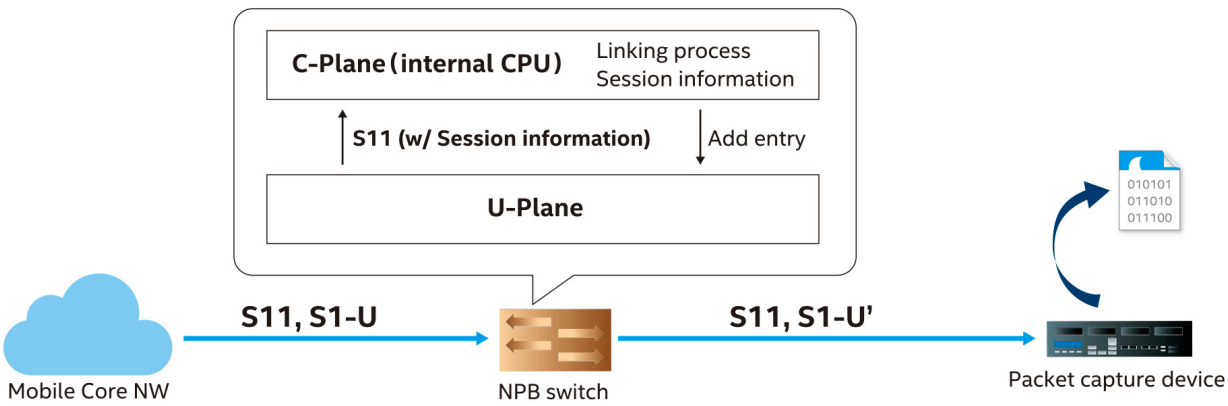


**Figure 5.** In-depth look at packet flow through KDDI NPB.

## Conclusion

KDDI needed a new packet capture capability to quickly respond to network trouble spots and provide excellent customer service for 5G customers. There are a significant number of commercial NPB products on the market, but KDDI wanted a streamlined NPB that offered just a select few features with more filtering flexibility and high performance.

The CoSP found that the programmability of P4 switches made a perfect platform for its NPB. With line rate throughput up to 100Gbps, the platform met the needs of today's network, but also it could grow to support new stand-alone 5G networks. It chose the Intel Tofino-based Wedge100BF-32X bare-metal switch, which provided the right cost, port count, small size and switching and compute functionality that the NPB required.

KDDI sought faster packet isolation, filtering and analysis and with its new NPB solution, the CoSP has reduced its packet troubleshooting time from four hours or more to 30 minutes. The streamlined NPB solution based on the Intel Tofino programmable Ethernet switch ASIC and Intel Xeon processor D-1517 utilized in the Edgecore Networks Wedge100BF-32X programmable switch met the goals that KDDI set in place for its development.

## Learn More

KDDI Corporation

Intel Tofino Programmable Ethernet Switch ASIC

Edgecore Networks Wedge100BF-32X

P4.org