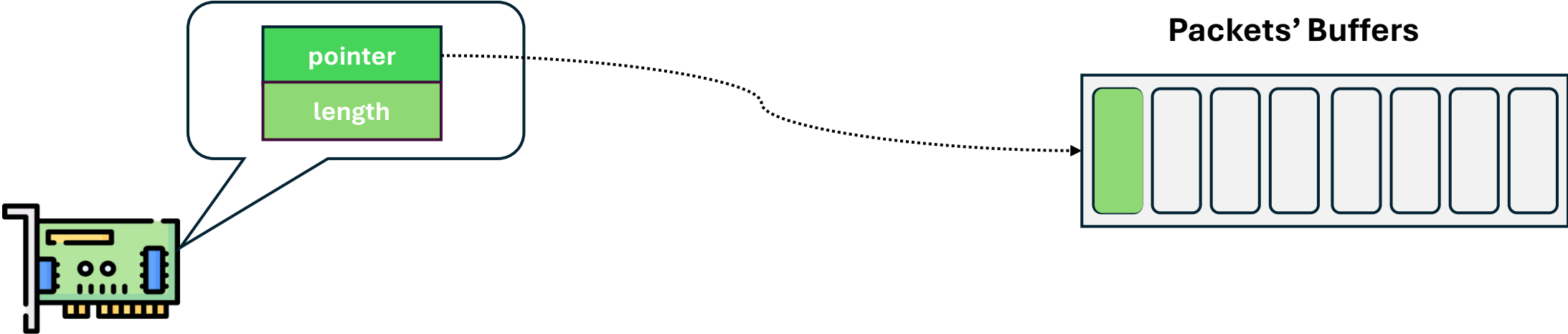


# OpenDesc: Describing NIC-Host Interfaces

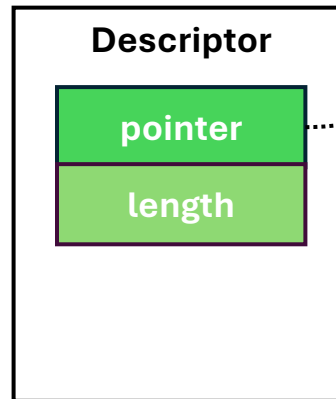
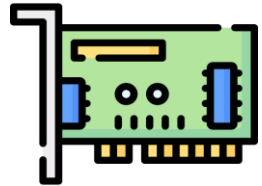
Seyyidahmed Lahmer, Nikita Tyunyayev, Tom Barbette



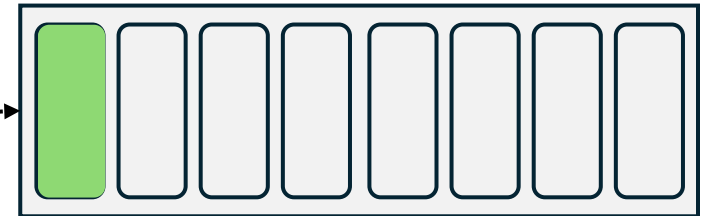
# NIC packet reception *in the old days*



# Packet descriptor

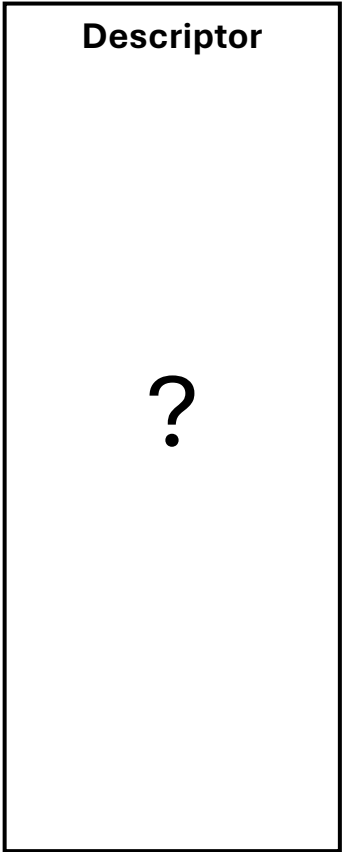
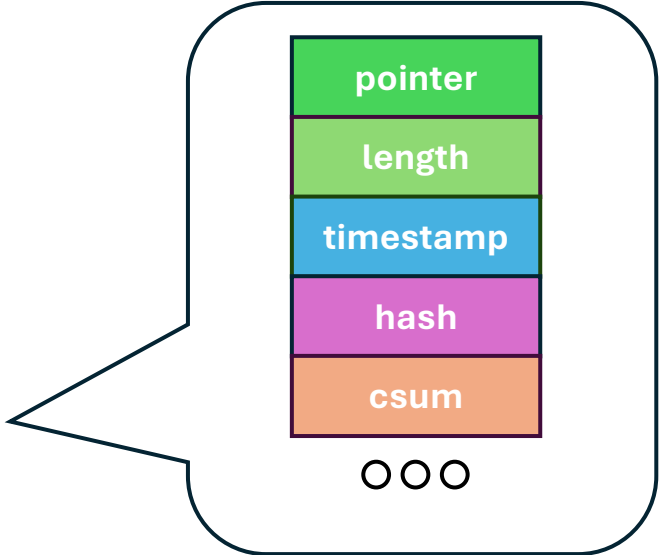
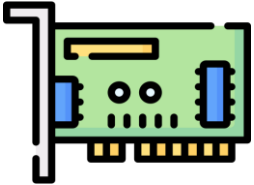


Packets' Buffers



*sk\_buff, rte\_mbuf, xdp\_md, ...*

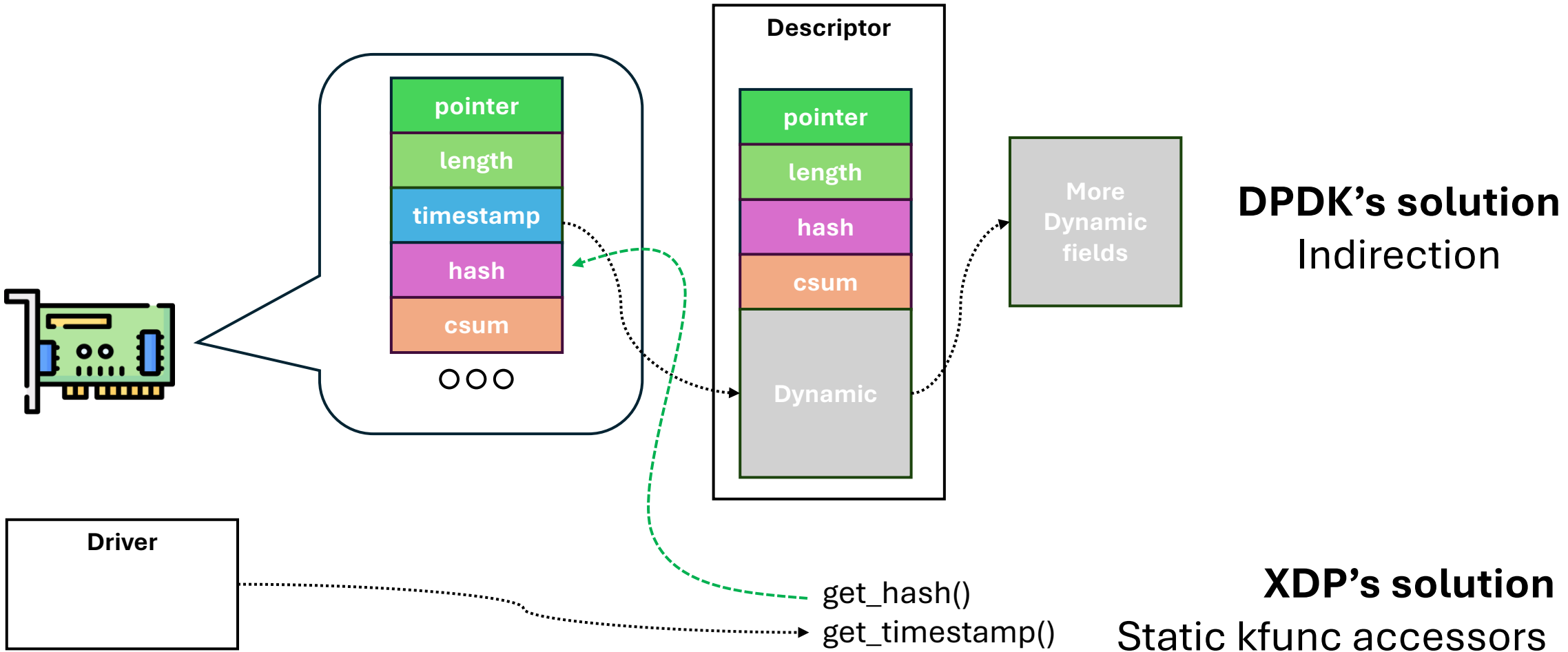
# Increasing NIC capabilities



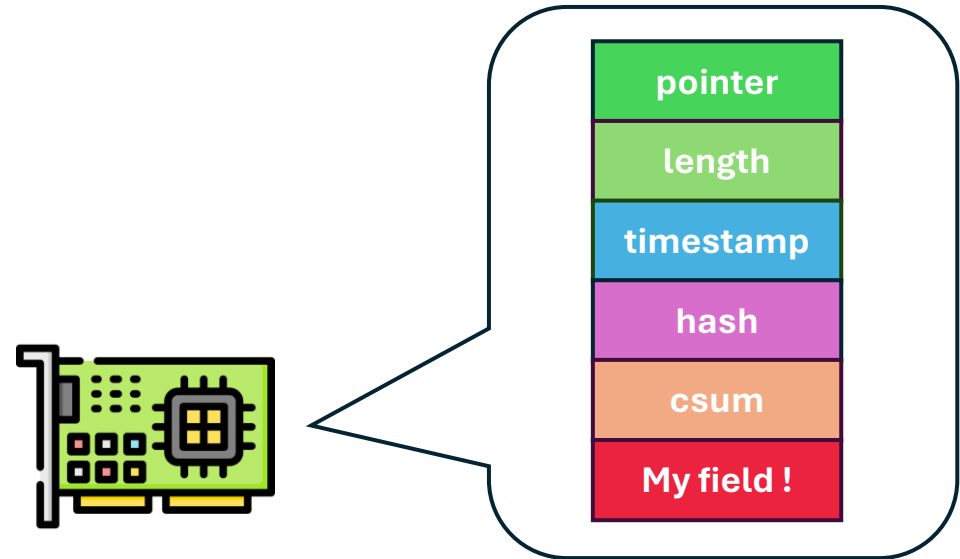
**Should we have place for everything in the descriptor?**

**Should the NIC always send every metadata?**

# Current approaches

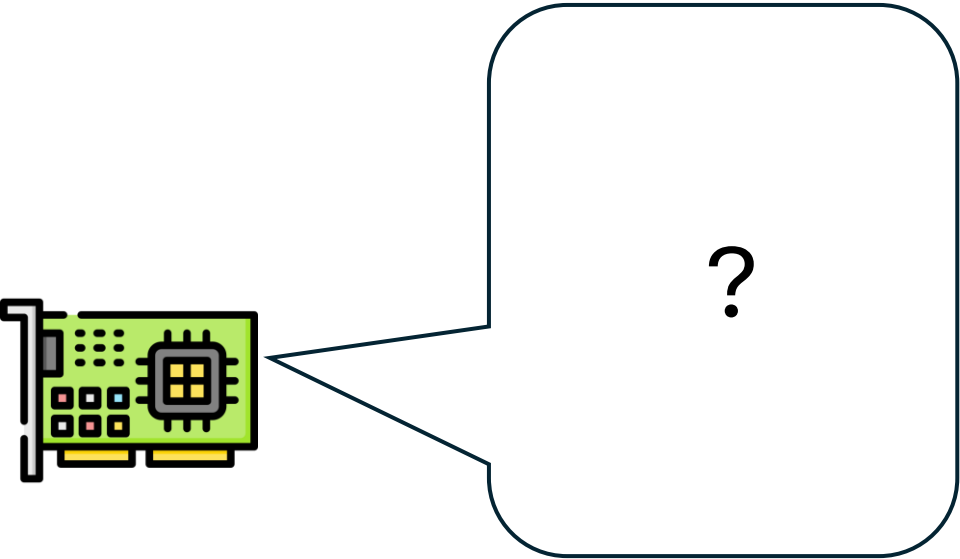


# Programmable NICs

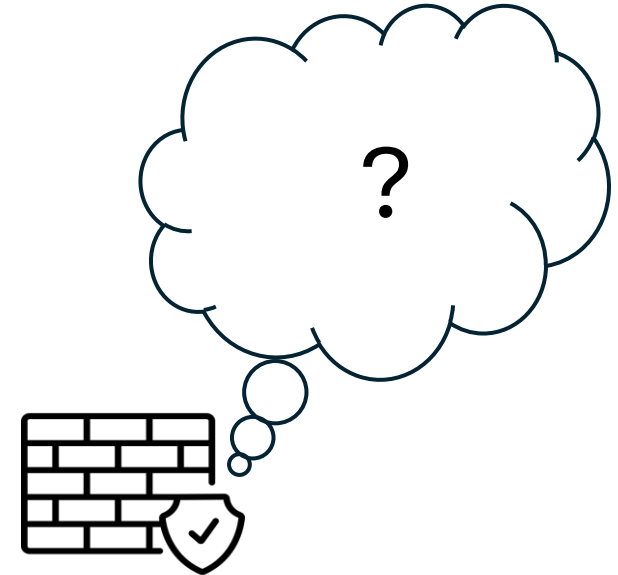
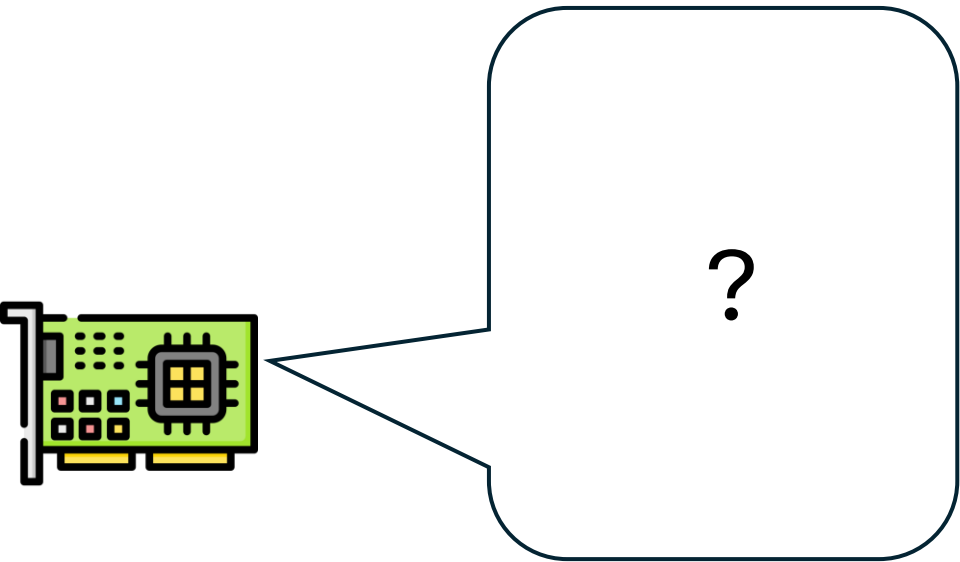


Needs a dynamic solution

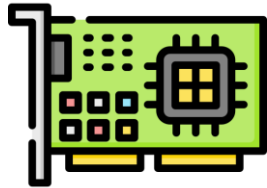
# What does the NIC provide?



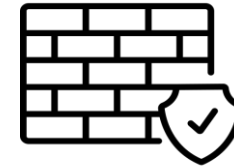
# What does the application actually need?



# OpenDesc



mlx5-descriptor.p4



my-app-intent.p4

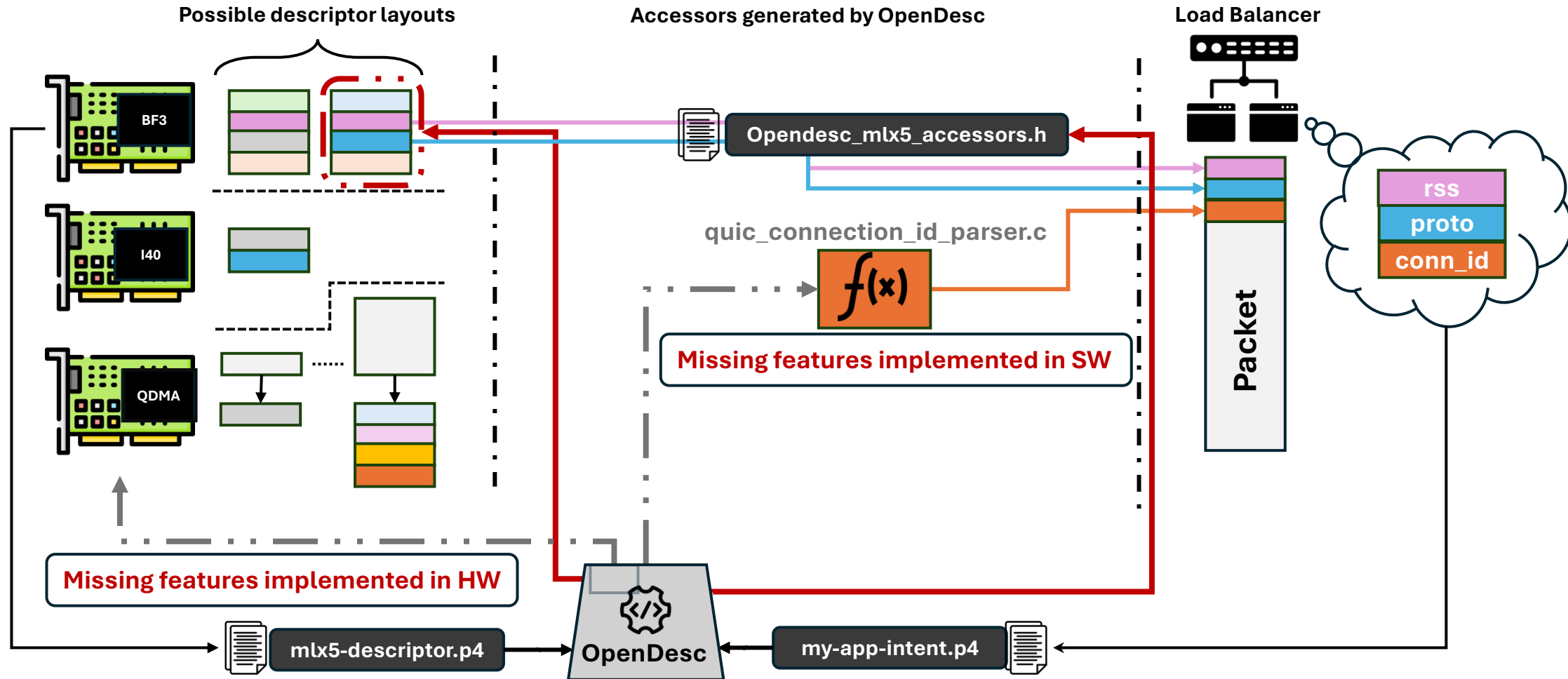


## OpenDesc:

- **NIC declare/annotate capabilities (P4).**
- **App declares fields of interest (P4),**
- **Generate accessors**
  - **SW missing caps**
  - **HW missing caps**

OpenDesc connects NIC capabilities with application needs through auto-generated metadata accessors.

# The OpenDesc Architecture



# OpenDesc Compiler Prototype

## 1. Frontend

- *NIC descriptor files* (e.g., `e1000-descriptor.p4`)
- *Application intent files* (e.g., `app-intent.p4`)

## 2. Backend

- *Accessor headers* (`opendesc_<nic>_accessors.h`)
- *Lists unsupported annotations for software implementations*

```
@card2host  
CmptDeparser( cmpt_out out,  
c2h_ctx_t ctx, in h2c_desc_t  
dh, in meta_t m){
```

```
apply{  
  out.emit(m.pkt_info);  
  out.emit(m.hdr_info);  
  if (ctx.use_rss == 1) {  
    out.emit(m.rss_hash);  
  } else {  
    out.emit(m.ip_id);  
    out.emit(m.csum);  
  }  
  out.emit(m.status_error);  
  out.emit(m.length);  
  out.emit(m.vlan);  
}  
}
```

```
header intent_t {  
  @opendesc("rss")  
  bit<32> rss_val;  
  @opendesc("vlan")  
  bit<16> vlan_tag;  
  @opendesc("ip_csum")  
  bit<16> csum;  
}
```

# Discussion

- Why P4?
  - Already used to describe NIC programs
  - Existing HW and SW compilers
  - Limitations : stateful, payload  
→ externs
- Performance considerations
  - To offload or not to offload [HotNets'25]
  - Clara[NSDI'22], Pipeleon[ATC'21], PIX[NSDI'22], ...
- Towards datapath generation
  - Use TinyNF[OSDI'20], ASNI[CoNEXT'25], ENSO[OSDI'23]?

## OpenDesc: From Static NIC Descriptors to Evolvable Metadata Interfaces

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### Abstract

Modern NICs offer rich functionalities, but host-side software lacks a unified way to express or adapt to their capabilities. Instead, developers rely on device-specific code and ad-hoc glue layers, leading to duplication, reduction to the lowest common denominator, inefficiency, and poor reuse. As NICs grow more flexible, the lack of a shared interface description becomes a core architectural bottleneck.

We propose **OpenDesc**, a common description interface based on P4. While P4 is typically used to define the data plane, we additionally repurpose it to allow the NIC and host to describe their roles in packet exchange.

The host declares an intent, specifying what functionalities should be implemented by the NIC. Fixed-function NICs describe what functionalities they can provide and their interface. Programmable NICs describe the constraints of their interface. OpenDesc uses the combinations of intents and capabilities to select a NIC-compatible descriptor format and

### CCS Concepts

• **Networks** → **Network adapters**; **Programmable networks**; • **Software and its engineering** → Source code generation.

### Keywords

SmartNIC, Offload, P4, Metadata Interface

### ACM Reference Format:

Seyyidahmed Lahmer, Nikita Tyunyayev, and Tom Barbette. 2025. OpenDesc: From Static NIC Descriptors to Evolvable Metadata Interfaces. In *The 24th ACM Workshop on Hot Topics in Networks (HotNets '25)*, November 17–18, 2025, College Park, MD, USA. ACM, New York, NY, USA, 9 pages. <https://doi.org/10.1145/3772356.3772418>

### 1 Introduction

Modern network interfaces have outgrown their original role. Once simple *Dumb DMA* engines, NICs now carry out a wide

# Questions