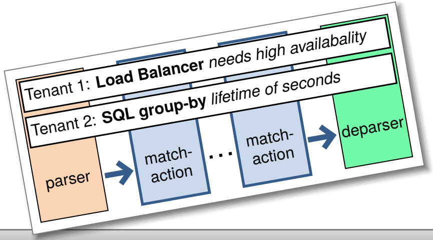

Tenant 1: **Load Balancer** *needs high availabality*

Tenant 2: **SQL group-by** *lifetime of seconds*

parser → match-action … match-action → deparser

Online Reprogrammable Multi Tenant Switches

Johannes Krude[1], Jaco Hofmann[2], Matthias Eichholz[2], Klaus Wehrle[1], Andreas Koch[2], Mira Mezini[2]

[1] RWTH Aachen University, [2] Technische Universität Darmstadt

DFG Collaborative Research Centre 1053 – MAKI
Multi Mechanism Adaptation for the Future Internet

https://comsys.rwth-aachen.de/

ENCP '19, 2019-12-09

Programmable Switch as a Service

- **On switch …**
  - …stateful load balancer **replaces hundreds of servers** [SilkRoad 2017]
  - …data aggregation **speeds up databases** [Lerner et.al. 2019, …]
  - …paxos **reduces coordination overhead** [NetChain 2018, …]
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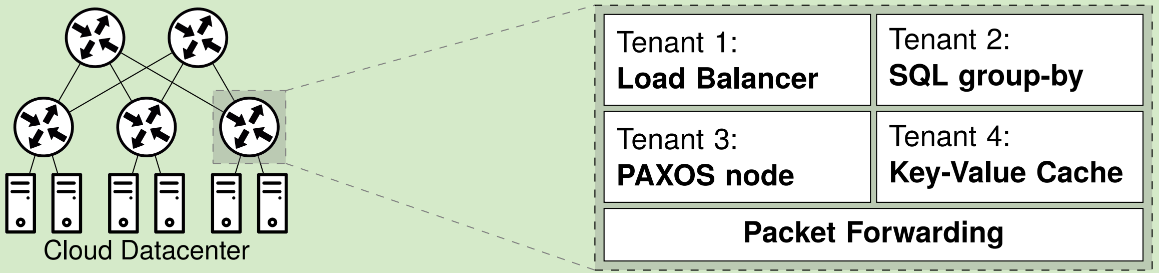


Tenant 1: **Load Balancer**

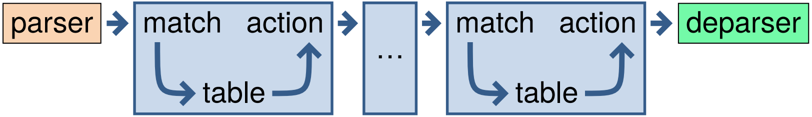
Tenant 2: **SQL group-by**

Tenant 3: **PAXOS node**

Tenant 4: **Key-Value Cache**

Packet Forwarding

Current Programmable Switch Pipeline [RMT 2013, Barefoot Tofino]



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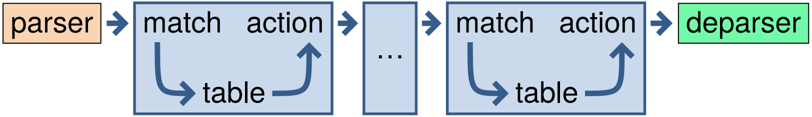

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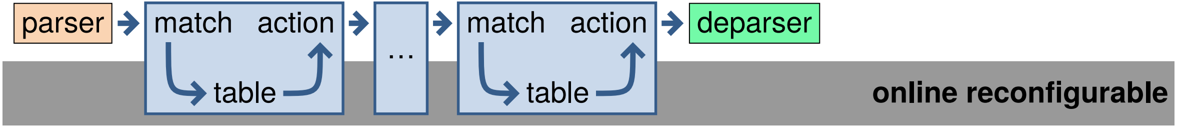

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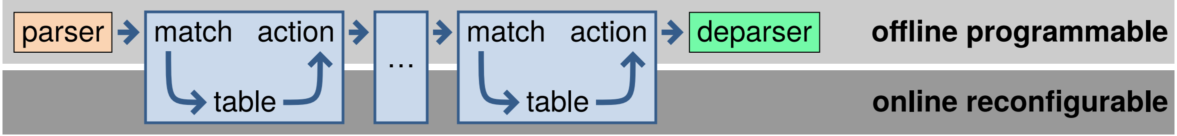

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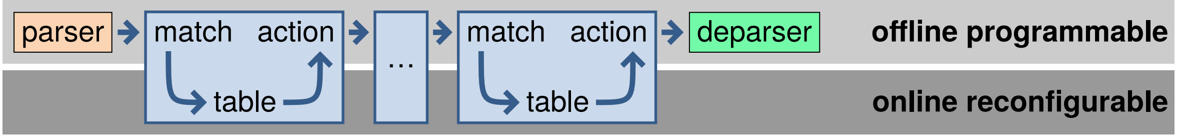

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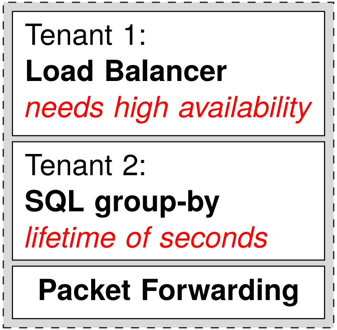
We propose to modify the programmable switch architecture

- To enable hot-pluggability of on-switch functions

Hot-Pluggability

Definition

The ability to insert, modify, and remove on-switch functions without affecting other on-switch functions and packet forwarding.



Programmable Switch

Hot-Pluggability

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Related Work

- **Use a dedicated switch for each application** [PPS 2019]
- **Put generalized functionality permanently onto switches** [NetAccel 2019, Ports et al. 2019]
- **Emulate P4 in Match-Action Tables** [Hyper4 2016, HyperVDP 2019]
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We want: **Switch Sharing** & **On-Demand Instantiation** & **Individual Customization**

Switch Architecture Requirements

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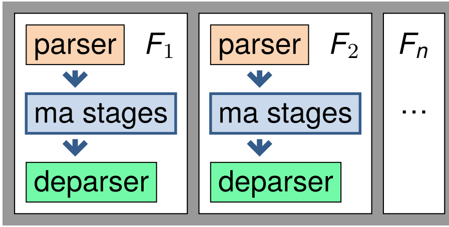
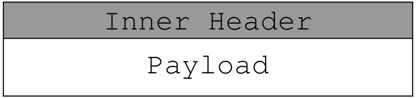
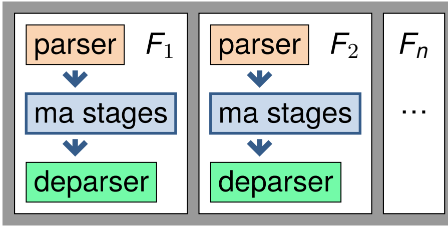


- **Multiple functions**
  - Hot-pluggable

Switch Architecture Requirements

Packet Structure





- **Multiple functions**
  - Hot-pluggable
  - Custom (de)parser

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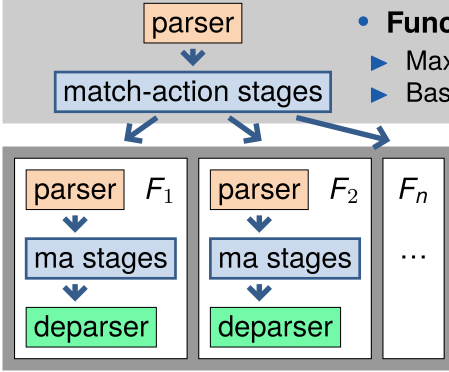
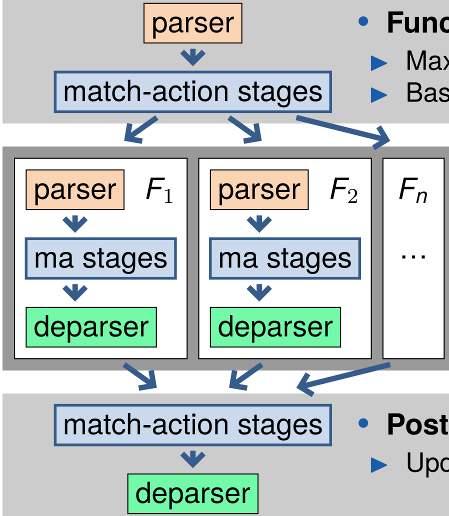


- **Function selection**
  - ▶ Max one function per packet
  - ▶ Based on VXLAN, IP dst, …
- **Multiple functions**
  - ▶ Hot-pluggable
  - ▶ Custom (de)parser

Packet Structure

`Outer Header`
`Inner Header`
`Payload`

Switch Architecture Requirements



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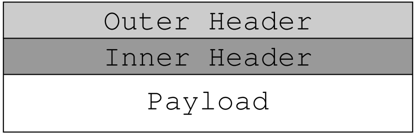

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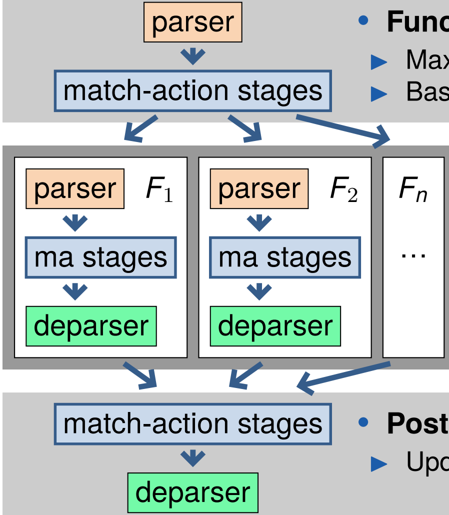

parser

match-action stages

parser F_1

ma stages

deparser

parser F_2

ma stages

deparser

F_n

…

match-action stages

deparser

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Packet Structure

Outer Header

Inner Header

Payload

- **Program isolation**
  - Access to only own packets
  - Limit access to outer header
  - Control plane virtualization

Realizing Online Reprogrammability

- **We present three different possible implementations**
  - None of them yet implemented

Multiple Switching ASICs

✓ Easily realizable

✗ No statefull functions

Using FPGAs

✓ Realizable with FPGA knowledge

✗ Reduced Throughput

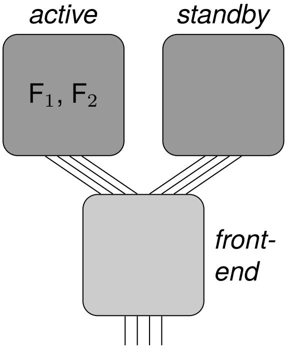
An ASIC extension

✗ To be done by switching ASIC vendors

✓ High performance

Multiple Programmable Switching ASICs

- **Alternate between two switching ASICs**



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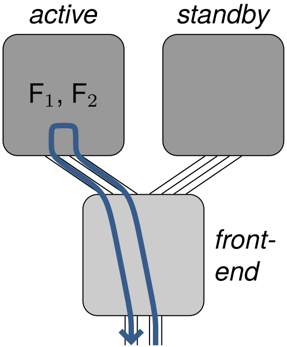

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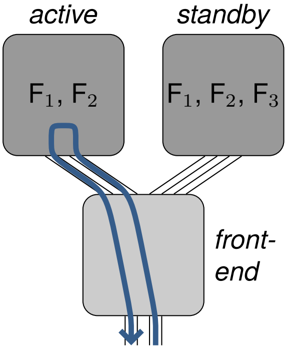

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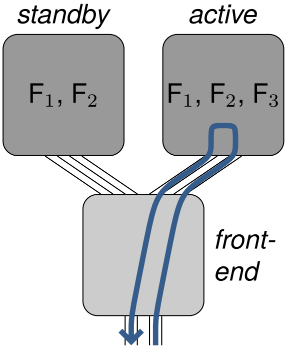

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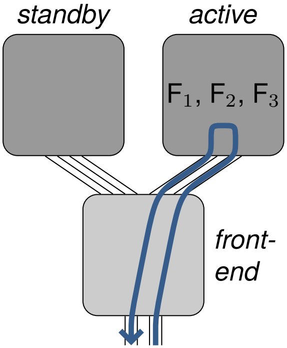

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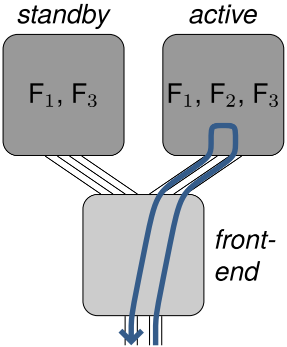

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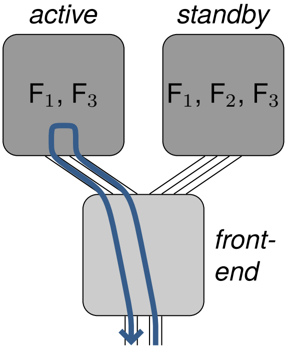

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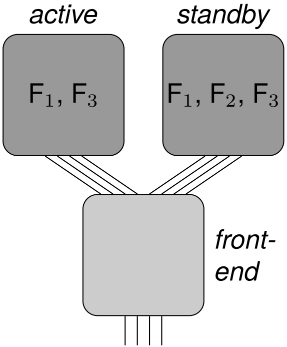

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  - ▶ Restricts access to outer headers
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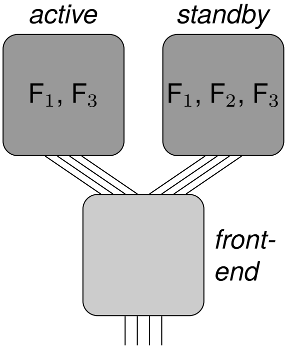

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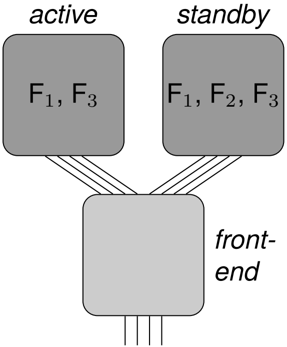

Advantages

✓ Based on available hardware

Limitations

✗ Problematic for statefull functions

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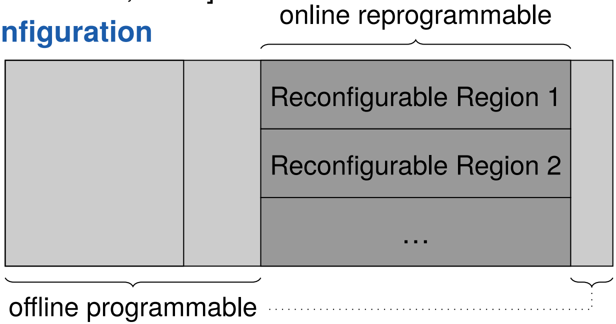

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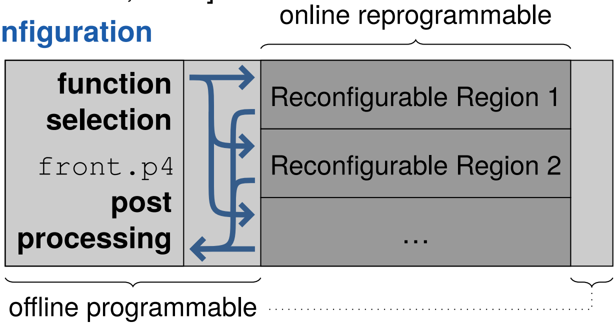

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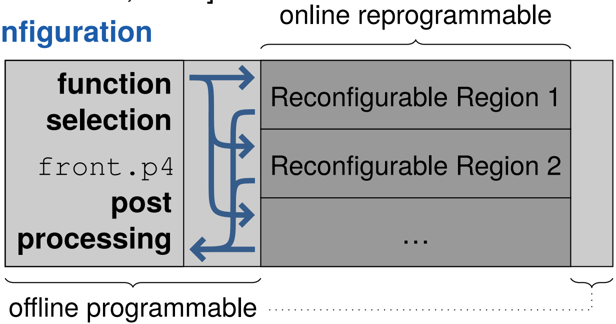

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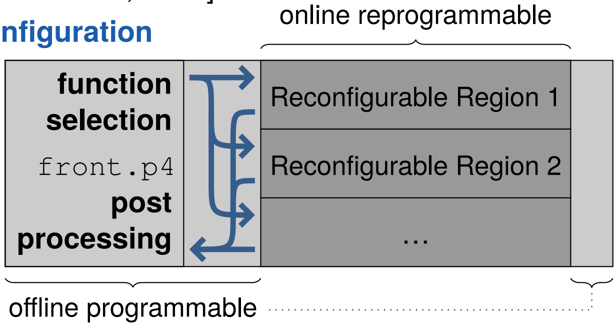

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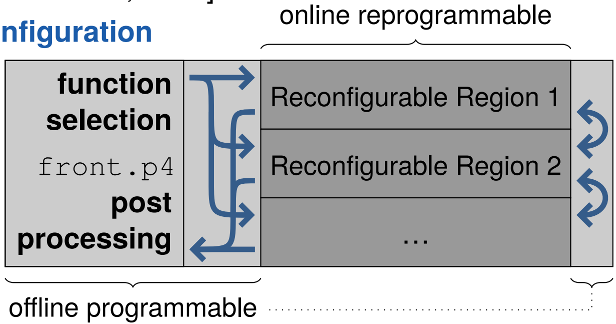

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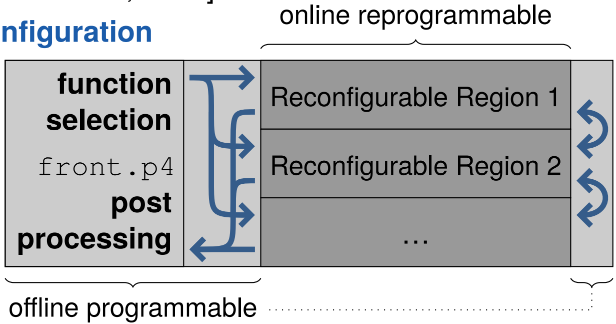

Advantages

✓ Readily available hardware

✓ Non-reconfigured regions keep state

Limitations

✗ Limited throughput

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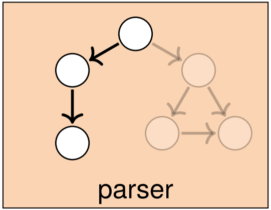

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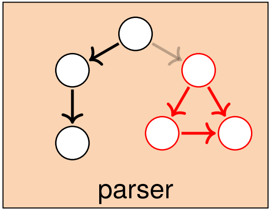

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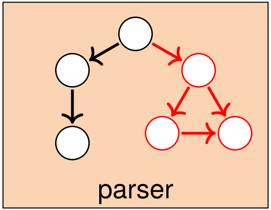

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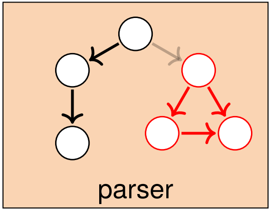

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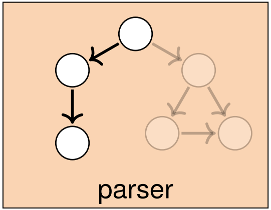

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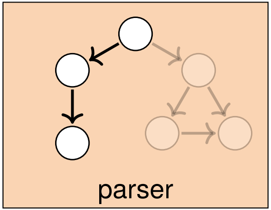

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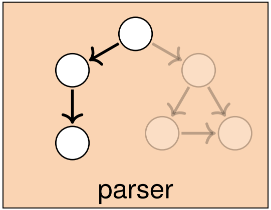

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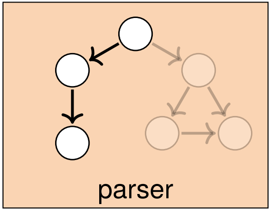

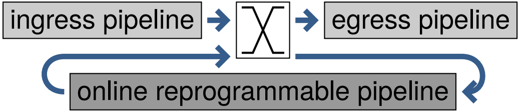

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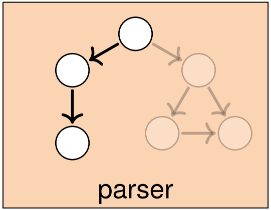

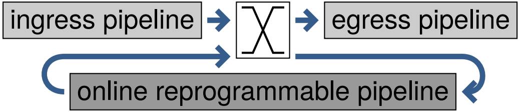
ingress pipeline

egress pipeline

online reprogrammable pipeline

Limitations

✗ Needs to be done by ASIC vendors

Advantages

✓ Same performace as current ASICs

Conclusion

- **Online reprogrammibility is needed for ”Programmable Switches as a Service“**
- **We propose an architecture for online reprogrammibility**
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New interesting resource management questions

- Measuring & accounting resource usage
- Resource allocation
- Avoiding resource fragmentation
- …