daPIPE

Data Plane Incremental Programming Environment

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Data Center Switching Group

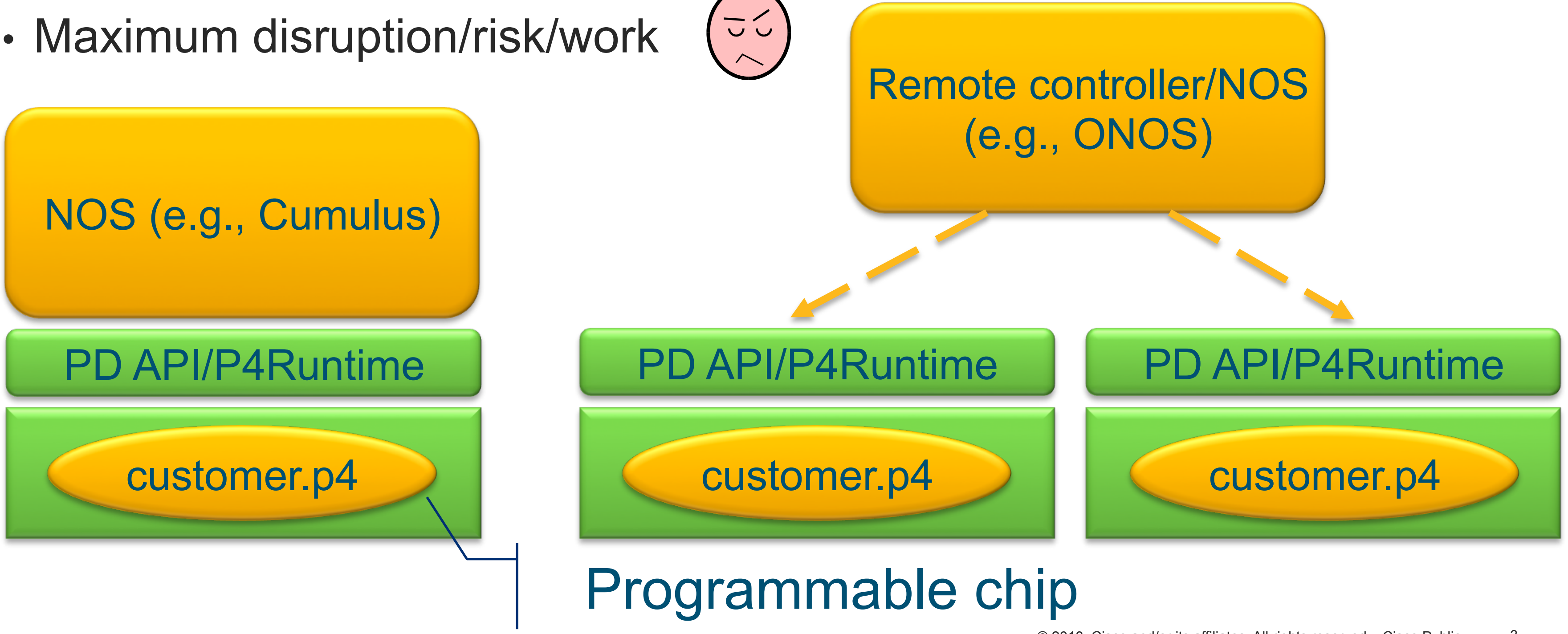
Programmable switches:

What are deployment options?

Whitebox Deployment

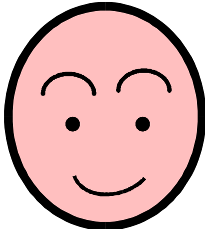
- 🟦 Platform vendor (Cisco)
- 🟩 Chip vendor (Barefoot)
- 🟨 Customer/open source

- Maximum flexibility ☺
- Maximum disruption/risk/work ☹



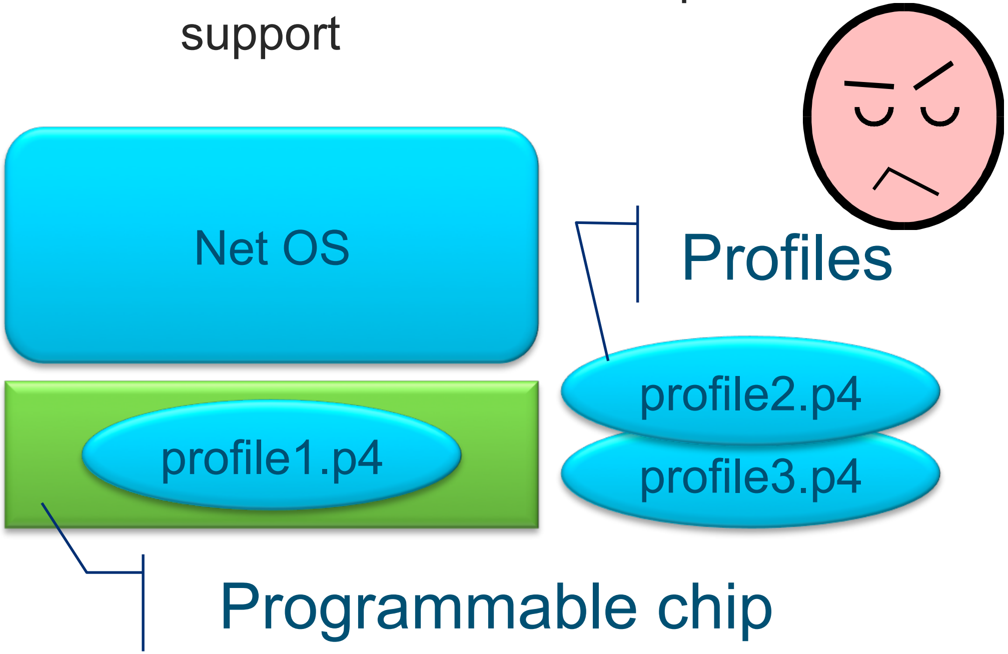
Turn-key Deployment

- Deployment as usual
  - Familiar features and interfaces
- Resource optimization
- Future proof
- Feature agility
- Streaming telemetry



🟦 Platform vendor (Cisco)
🟩 Chip vendor (Barefoot)
🟨 Customer/open source

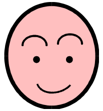
- No flexibility
  - No custom feature and protocol support



Hybrid Deployment

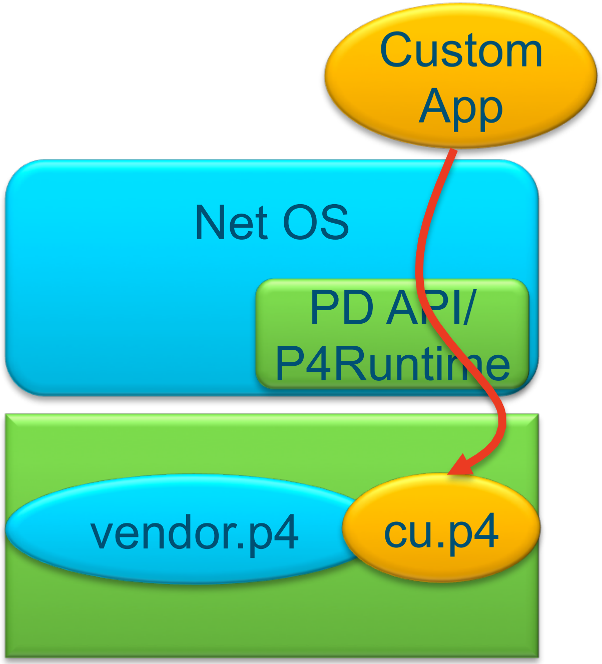
- 🟦 Platform vendor (Cisco)
- 🟩 Chip vendor (Barefoot)
- 🟧 Customer/open source/

- Best of breed



- Deployment as usual
  - Familiar features and interfaces
- Minimum development effort
  - Leverage existing functions in building new features

Minimize disruption and risk!



Challenges

Do not break what works

- Vendor data plane code is well tested
- … and we don't want to need regression testing

Don't want to show, don't want to see

- Vendor code and custom code may be confidential
- Not practical to familiarize with a lot of vendor code to just write a few lines

Resource availability

- Still "limited" on current chips

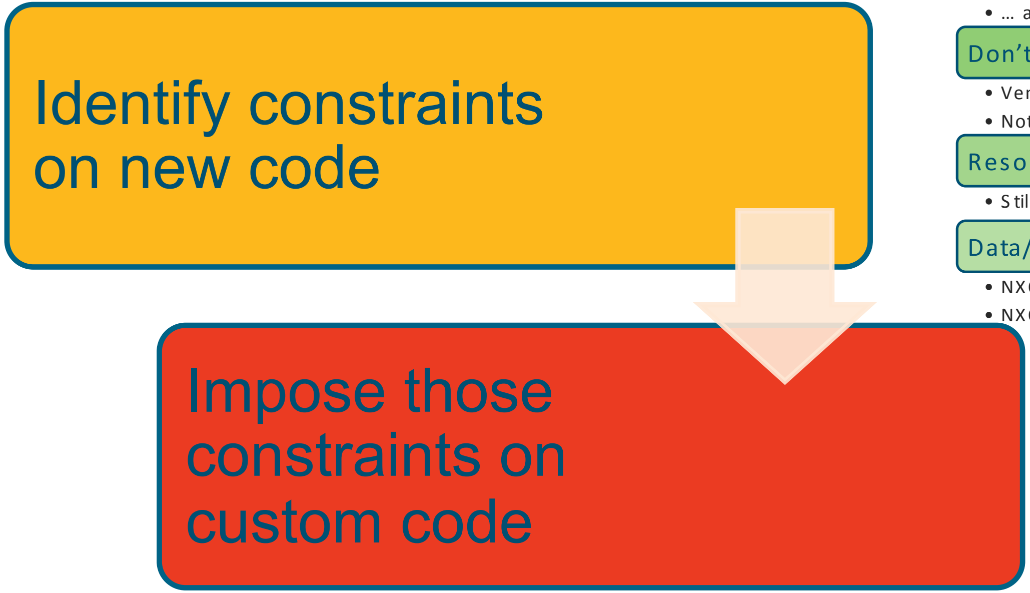
Data/control plane dependence

- Net OS should keep working
- Net OS should not be aware of custom data plane functions

In a nutshell, we need an explicit effort to support

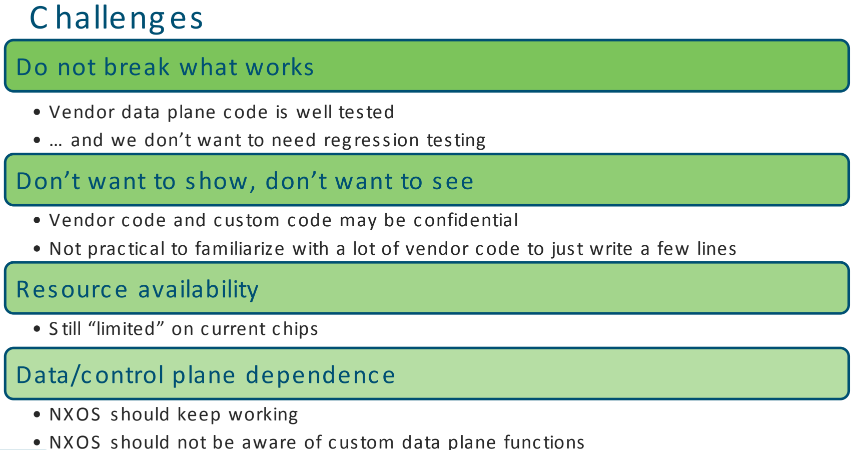
Incremental Programming

How can we address these challenges?



Identify constraints on new code

Impose those constraints on custom code



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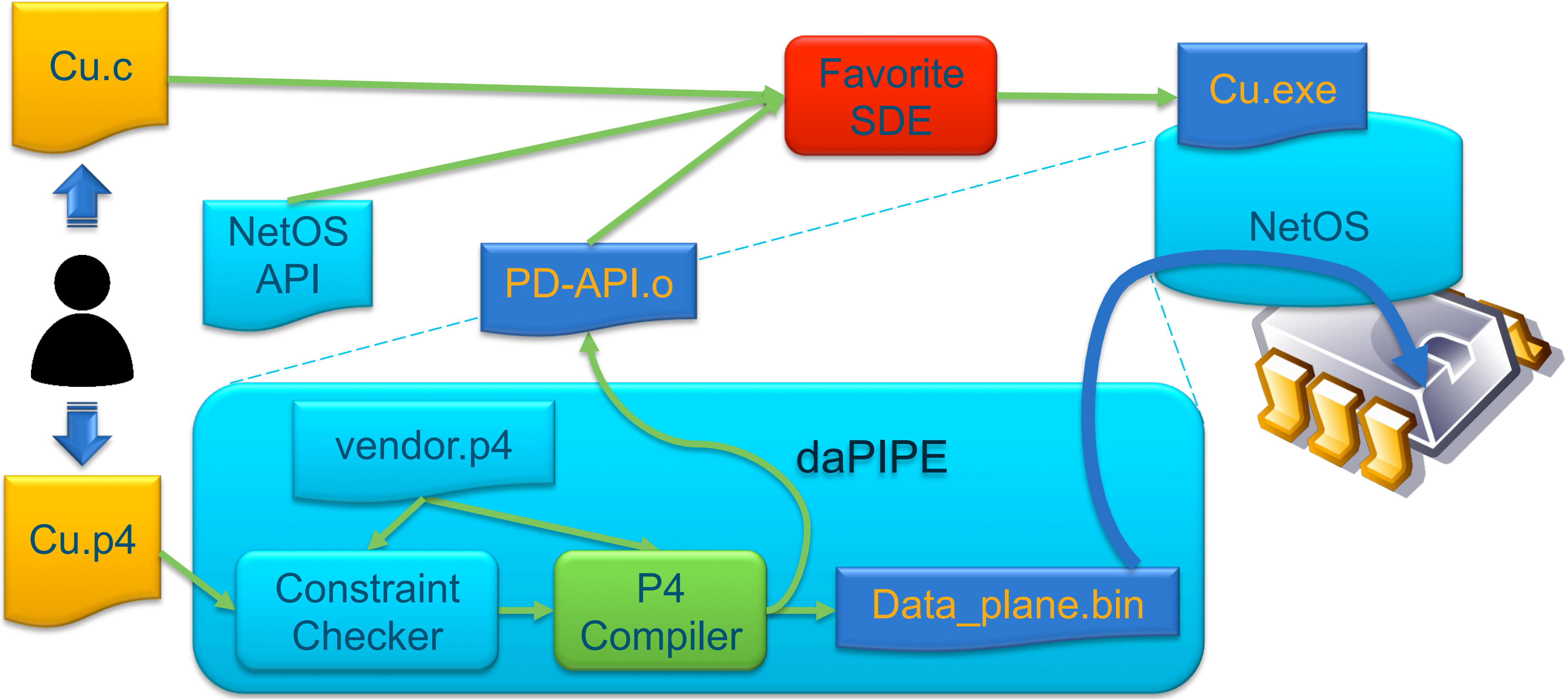
- Still “limited” on current chips

Data/control plane dependence

- NXOS should keep working
- NXOS should not be aware of custom data plane functions

Customer Programming Workflow



Cu.c

Favorite SDE

Cu.exe

NetOS API

PD-API.o

NetOS

vendor.p4

daPIPE

Cu.p4

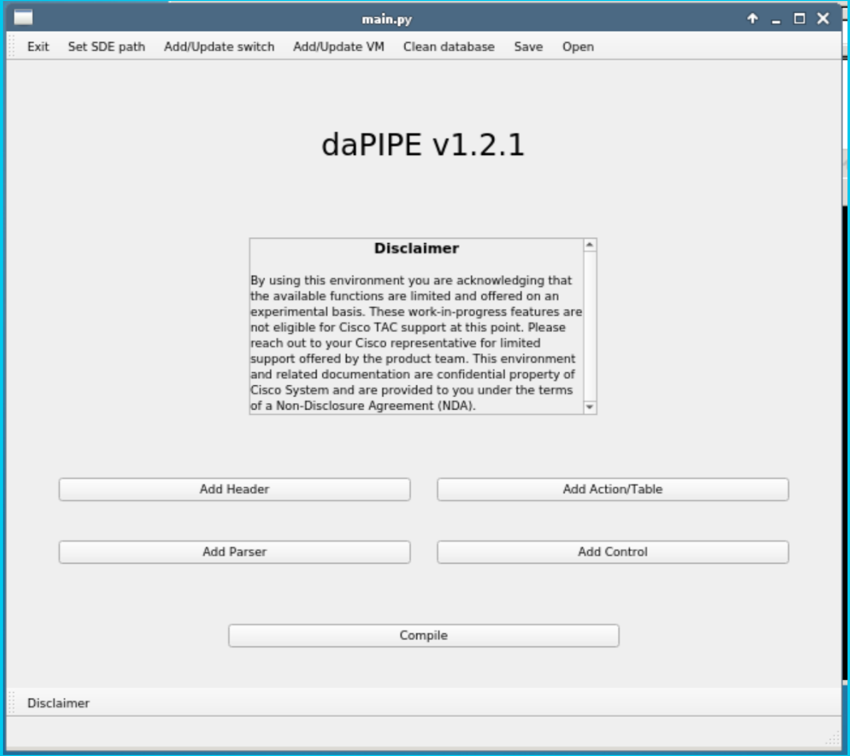
Constraint Checker

P4 Compiler

Data_plane.bin

daPIPE

Data Plane Incremental Programming Environment



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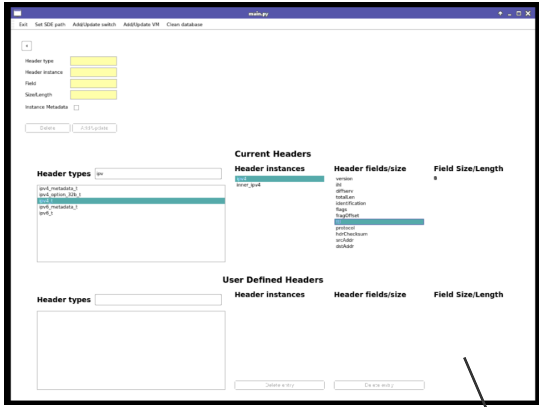
Support developers and streamline their task (while enforcing constraints)

Components of the Solution



Header type

Header instance

Field

Size/Length

Instance Metadata □

Current Headers

Header types ipv

ipv4_metadata_t
ipv4_option_32b_t
ipv4_t
ipv6_metadata_t
ipv6_t

Header instances

ipv4
inner_ipv4

Header fields/size

version
ihl
diffserv
totalLen
identification
flags
fragOffset
ttl
protocol
hdrChecksum
srcAddr
dstAddr

Field Size/Length

8

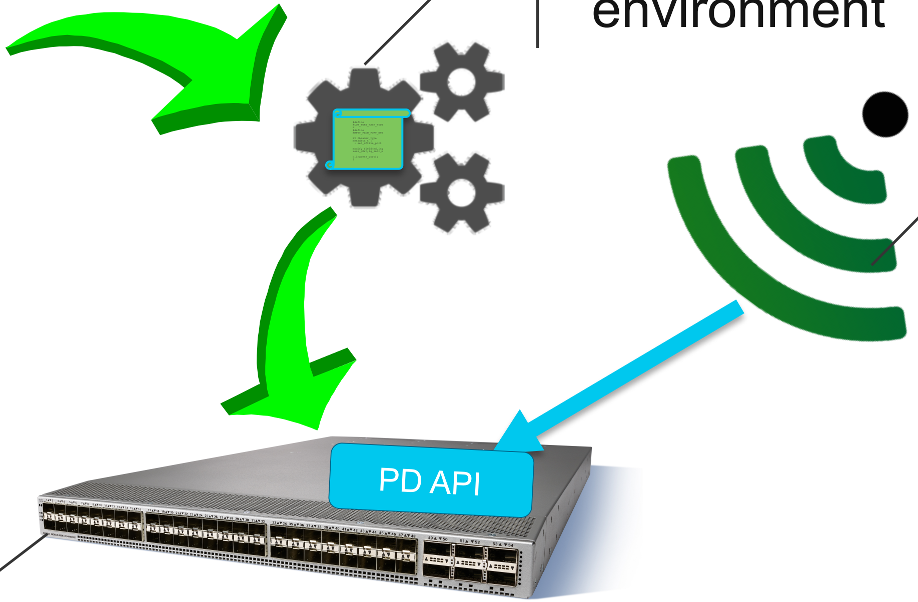
User Defined Headers

Header types

Header instances

Header fields/size

Field Size/Length



daPIPE build environment

Control program

daPIPE Graphical User Interface

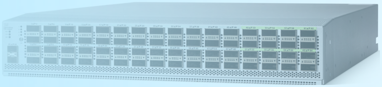
Nexus 34180YC

Nexus 3400 Programmable Switch Family

Shipping

48p 10/25Gb/s SFP + 6p 40/100Gb/s QSFP
Nexus 34180YC

Committed

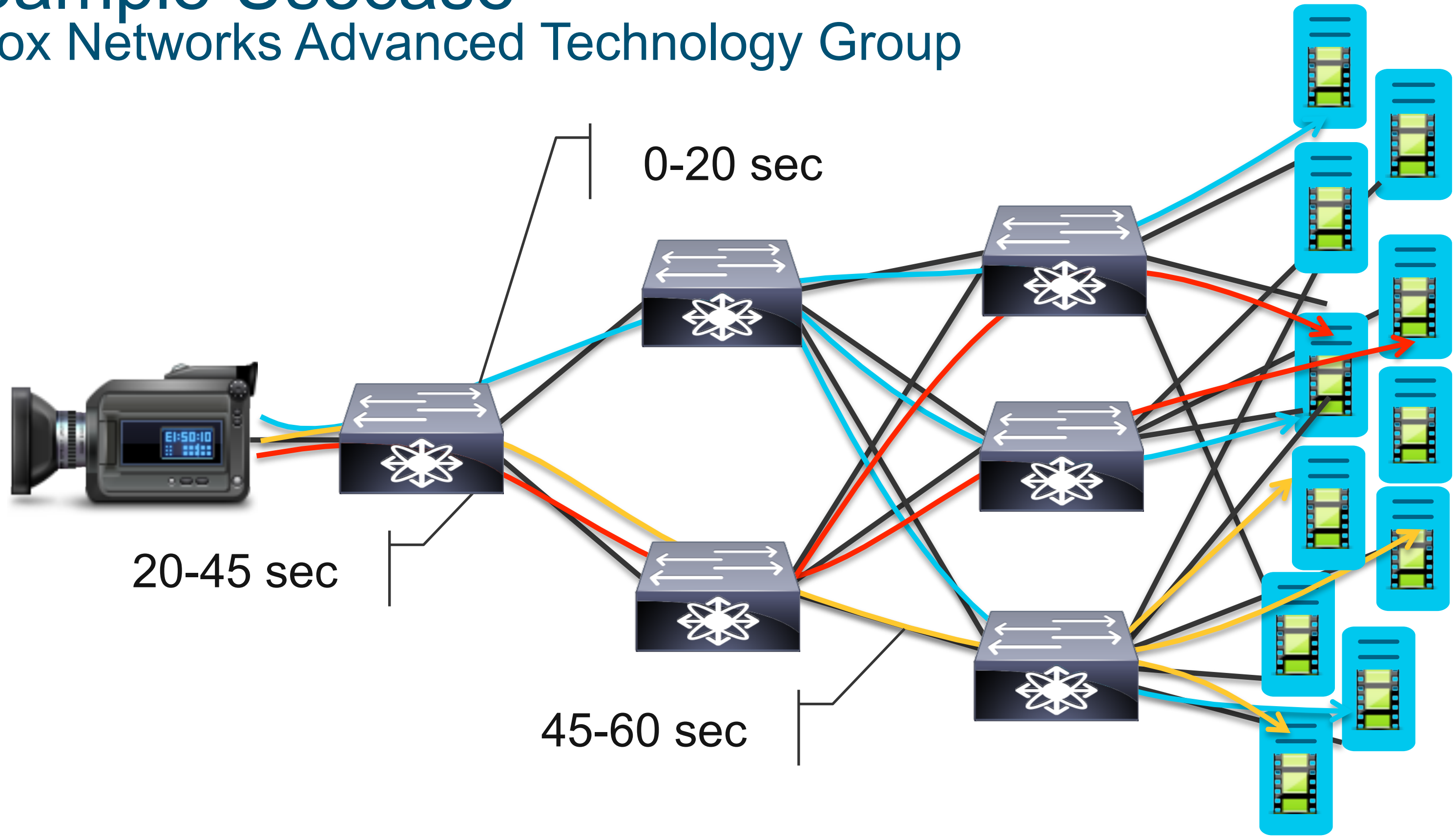


64p 40/100Gb/s QSFP
Nexus 3464C

- Based on Tofino 1 by Barefoot
- 1.8/6.4 Tb/s aggregated switching capacity
- Flexible port configuration and multiple profiles for addressing different feature and scale requirements
- Inband Network Telemetry (INT) support

daPIPE in Action

Sample Usecase
Fox Networks Advanced Technology Group



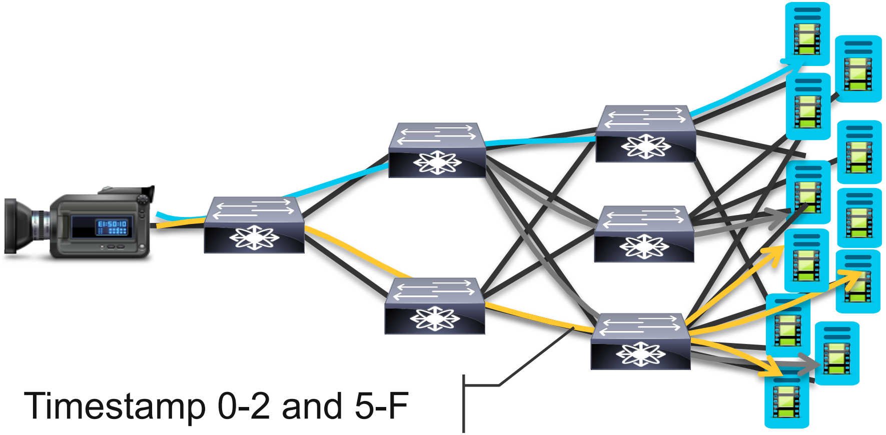
https://github.com/FOXNEOAdvancedTechnology/ts_switching_P4

Specification

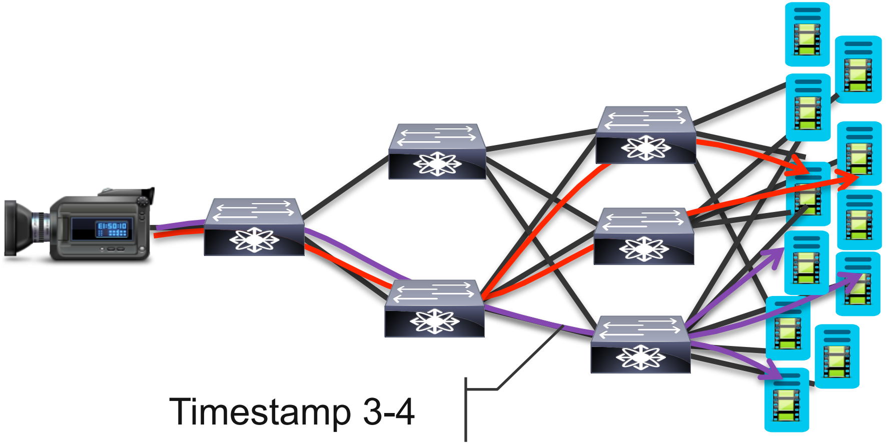
- A switch shall forward packets based on the RTP timestamp they contain

- If sent to 239.1.1.1, change destination address to 239.3.3.3 when RTP timestamp is
  - Between 0 and 2
  - Between from 5 and F

- If sent to 239.2.2.2, change destination address to 239.3.3.3 when RTP timestamp is
  - Between 3 and 4



Timestamp 0-2 and 5-F

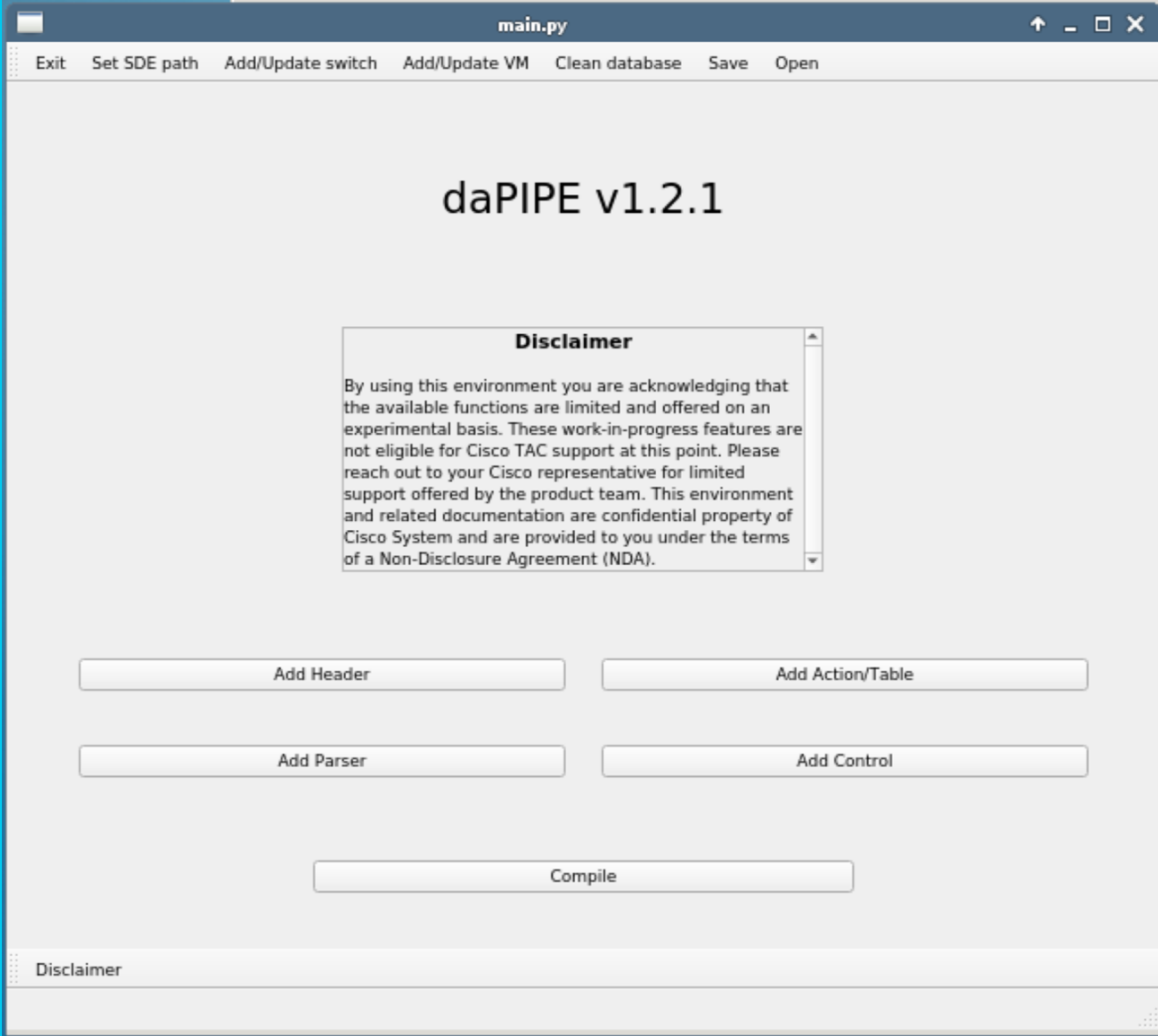


Timestamp 3-4

Development Workflow

- Browse available (stock) metadata
- Define custom headers and metadata
- Specify parser(s) and their hook(s) in existing (stock) parsers
- Define custom tables and actions
- Specify control flow
- Compile and load on chip
- Develop control plane functionalities

Main window



daPIPE v1.2.1

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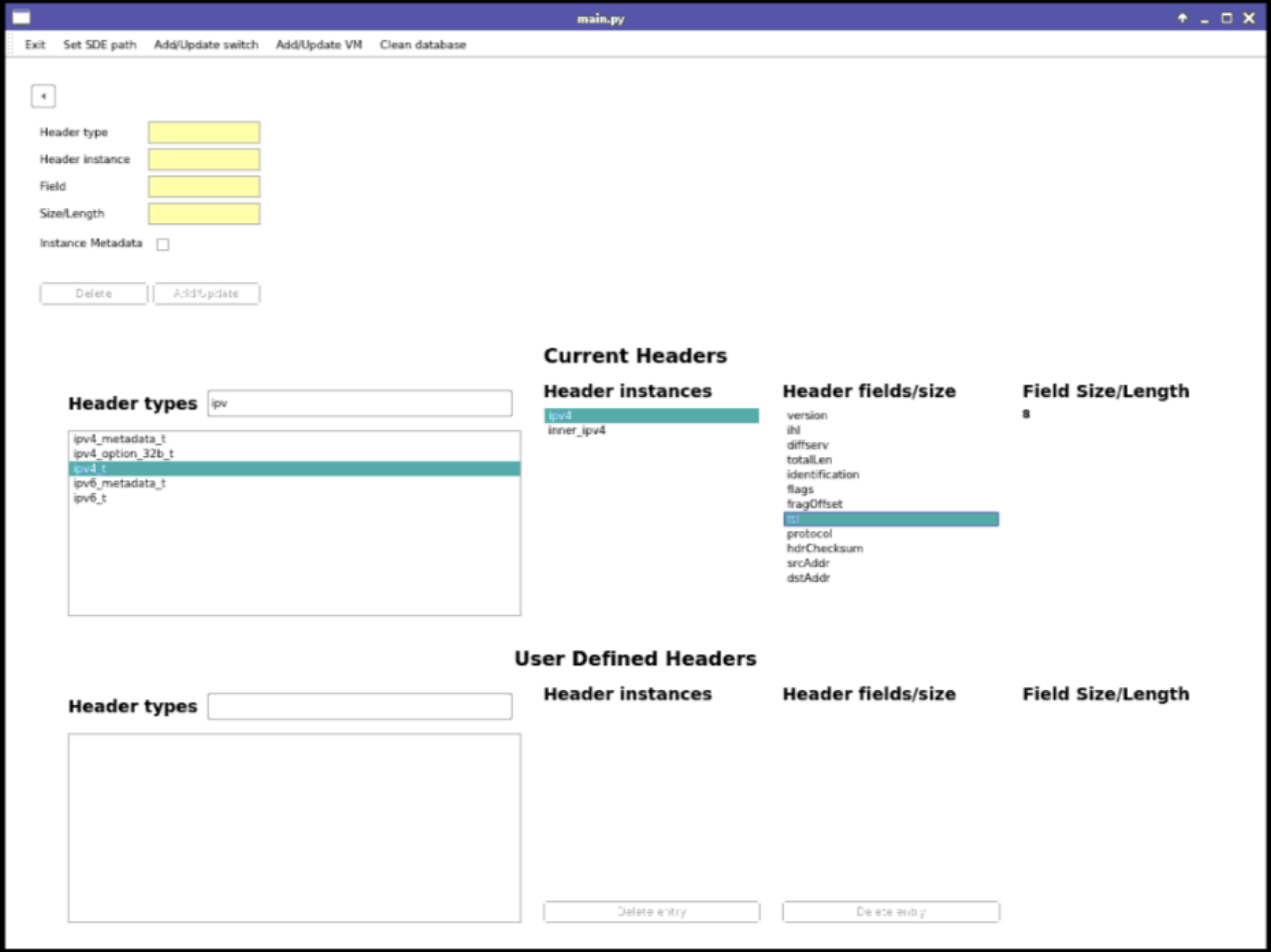
Existing header view



Current Headers

Header types: ipv

ipv4_metadata_t
ipv4_option_32b_t
ipv4_t
ipv6_metadata_t
ipv6_t

Header instances

ipv4
inner_ipv4

Header fields/size

version
ihl
diffserv
totalLen
identification
flags
fragOffset
ttl
protocol
hdrChecksum
srcAddr
dstAddr

Field Size/Length

8

User Defined Headers

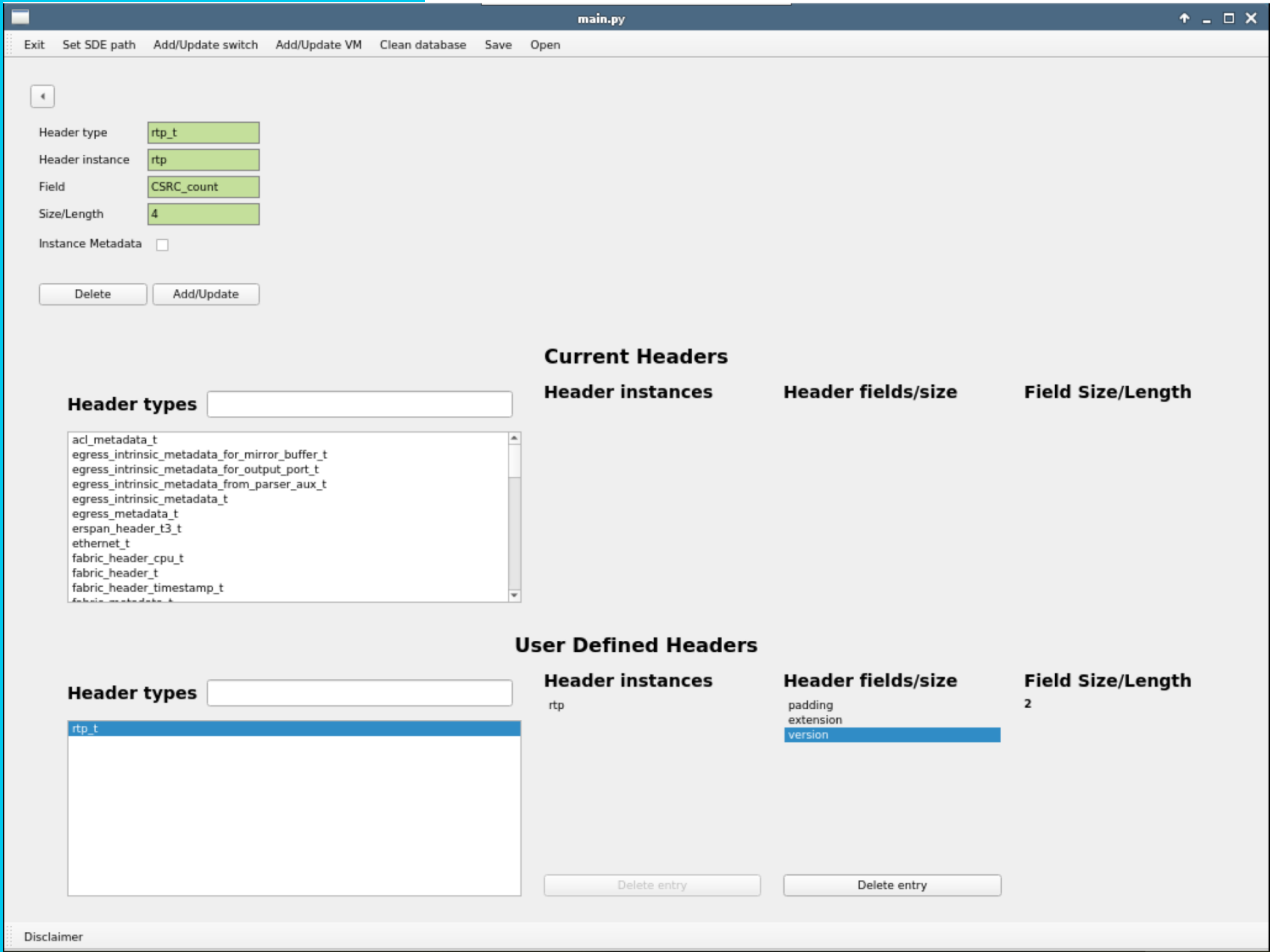
Header types

Header instances

Header fields/size

Field Size/Length

Adding RTP header



Header type: rtp_t

Header instance: rtp

Field: CSRC_count

Size/Length: 4

Instance Metadata □

Current Headers

Header types

acl_metadata_t
egress_intrinsic_metadata_for_mirror_buffer_t
egress_intrinsic_metadata_for_output_port_t
egress_intrinsic_metadata_from_parser_aux_t
egress_intrinsic_metadata_t
egress_metadata_t
erspan_header_t3_t
ethernet_t
fabric_header_cpu_t
fabric_header_t
fabric_header_timestamp_t

Header instances

Header fields/size

Field Size/Length

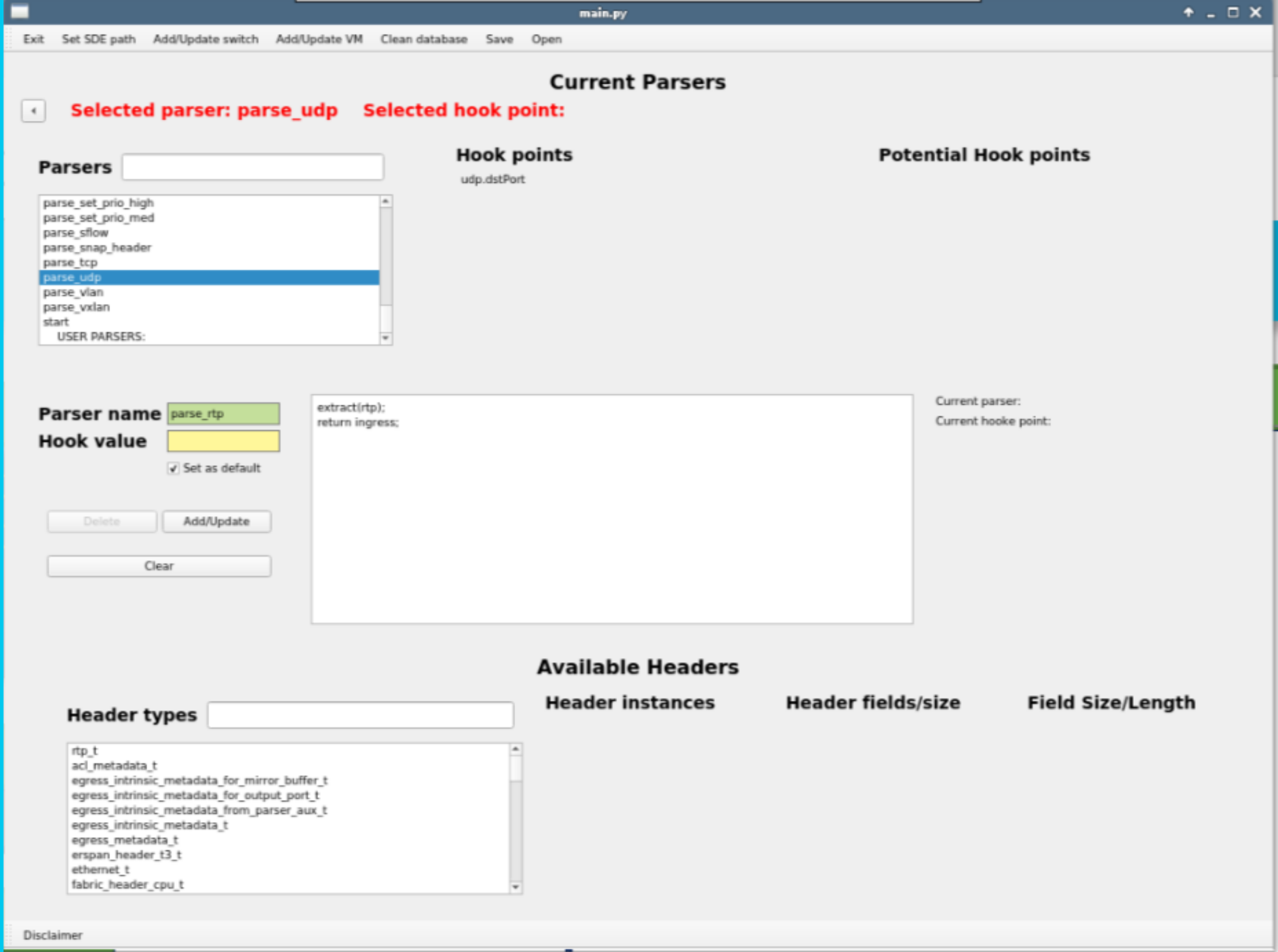
User Defined Headers

Header types

rtp_t

Header instances	**Header fields/size**	**Field Size/Length**
rtp	padding extension version	2

Adding RTP parser



Current Parsers

Selected parser: parse_udp Selected hook point:

Parsers

parse_set_prio_high
parse_set_prio_med
parse_sflow
parse_snap_header
parse_tcp
parse_udp
parse_vlan
parse_vxlan
start
USER PARSERS:

Hook points

udp.dstPort

Potential Hook points

Parser name: parse_rtp

Hook value:

☑ Set as default

```
extract(rtp);
return ingress;
```

Current parser:

Current hooke point:

Available Headers

Header types

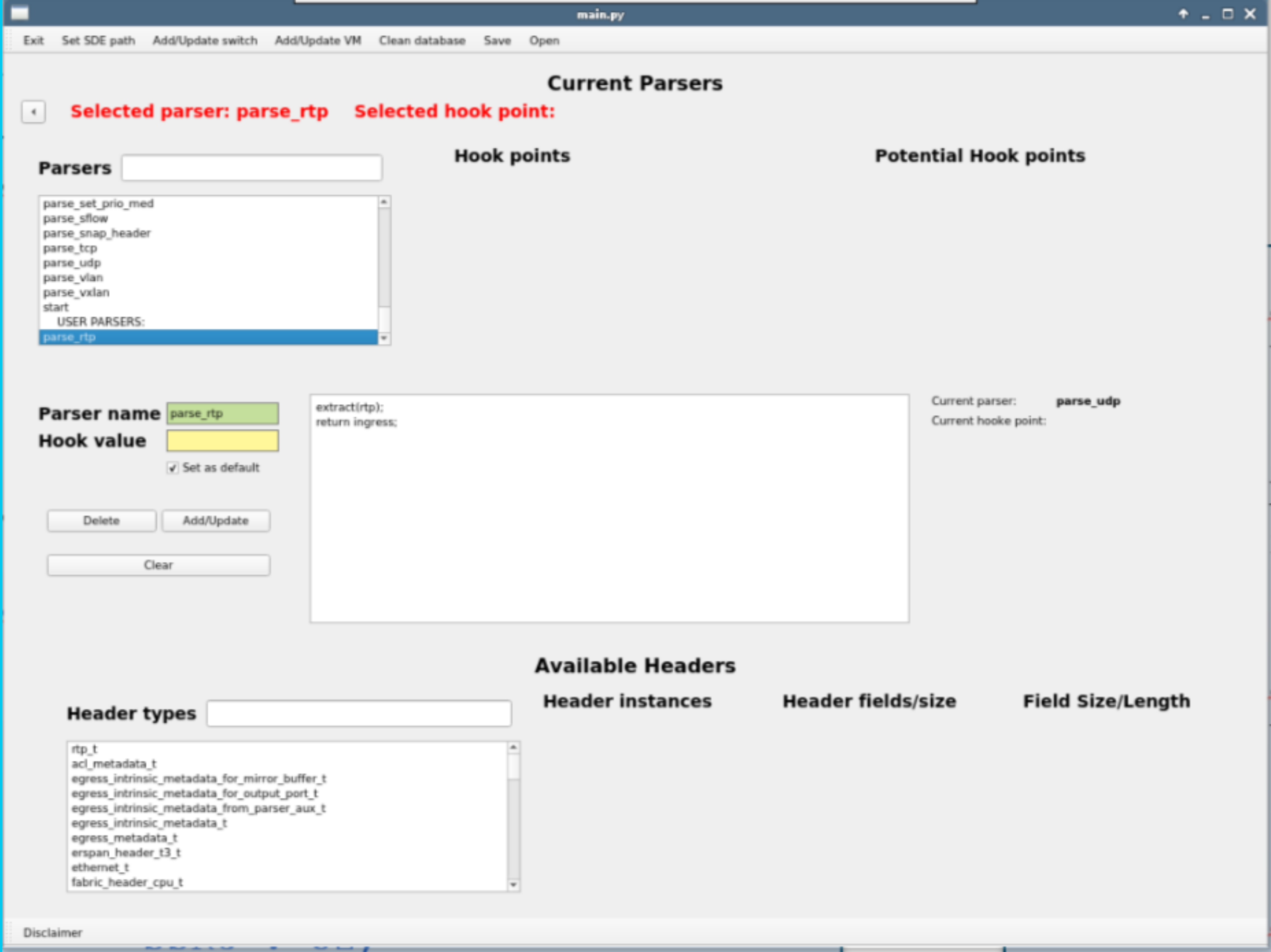
rtp_t
acl_metadata_t
egress_intrinsic_metadata_for_mirror_buffer_t
egress_intrinsic_metadata_for_output_port_t
egress_intrinsic_metadata_from_parser_aux_t
egress_intrinsic_metadata_t
egress_metadata_t
erspan_header_t3_t
ethernet_t
fabric_header_cpu_t

Header instances

Header fields/size

Field Size/Length

New parser added



Selected parser: parse_rtp Selected hook point:

parse_set_prio_med
parse_sflow
parse_snap_header
parse_tcp
parse_udp
parse_vlan
parse_vxlan
start
USER PARSERS:
parse_rtp

Parser name: parse_rtp

Hook value:

☑ Set as default

```
extract(rtp);
return ingress;
```

Current parser: parse_udp

Current hooke point:

rtp_t
acl_metadata_t
egress_intrinsic_metadata_for_mirror_buffer_t
egress_intrinsic_metadata_for_output_port_t
egress_intrinsic_metadata_from_parser_aux_t
egress_intrinsic_metadata_t
egress_metadata_t
erspan_header_t3_t
ethernet_t
fabric_header_cpu_t

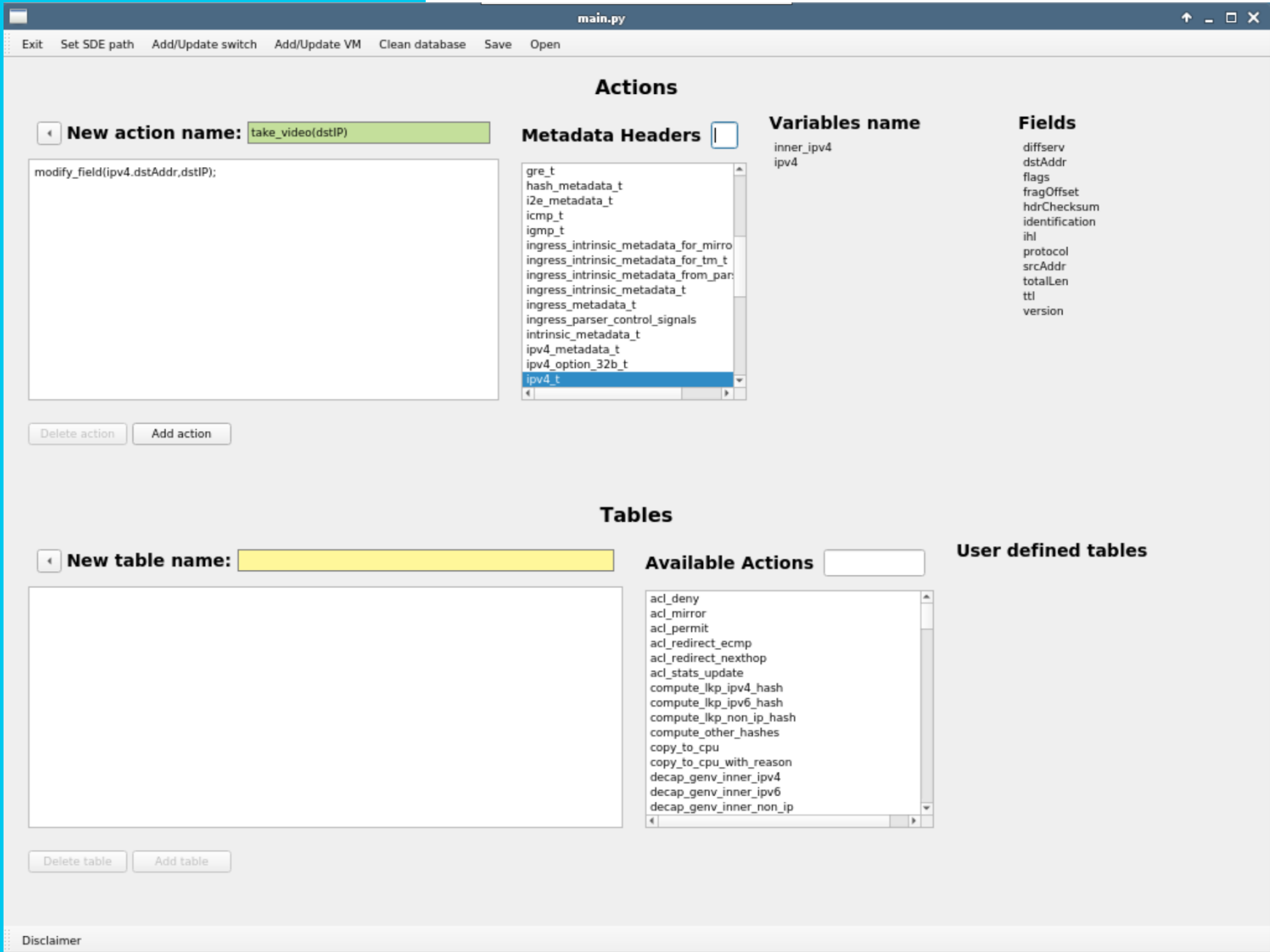
Resulting Parsing Code

Stock code
Custom code
Autom. code

```
...
header_type ethernet_t {
    fields {
        dstAddr : 48;
        srcAddr : 48;
        etherType : 16;
    }
}
header ethernet_t ethernet;
...
header_type rtp_t {
    fields {
        version : 2;
        padding : 1;
...
        sequence_number : 16;
        timestamp : 32;
        SSRC : 32;
    }
}
header rtp_t rtp;
...
```

```
...
parser parse_ethernet {
    extract(ethernet);
    return select(latest.etherType)
{
        ETHERTYPE_IPV4 : parse_ipv4;
        default: ingress;
   }
}
parser parse_udp {
    extract(udp);
    return parse_rtp;
}
...
parser parse_rtp {
    extract(rtp);
    return ingress;
}
...
```

Add action



New action name: take_video(dstIP)

```
modify_field(ipv4.dstAddr,dstIP);
```

Metadata Headers

- gre_t
- hash_metadata_t
- i2e_metadata_t
- icmp_t
- igmp_t
- ingress_intrinsic_metadata_for_mirro
- ingress_intrinsic_metadata_for_tm_t
- ingress_intrinsic_metadata_from_par:
- ingress_intrinsic_metadata_t
- ingress_metadata_t
- ingress_parser_control_signals
- intrinsic_metadata_t
- ipv4_metadata_t
- ipv4_option_32b_t
- ipv4_t

Variables name

- inner_ipv4
- ipv4

Fields

- diffserv
- dstAddr
- flags
- fragOffset
- hdrChecksum
- identification
- ihl
- protocol
- srcAddr
- totalLen
- ttl
- version

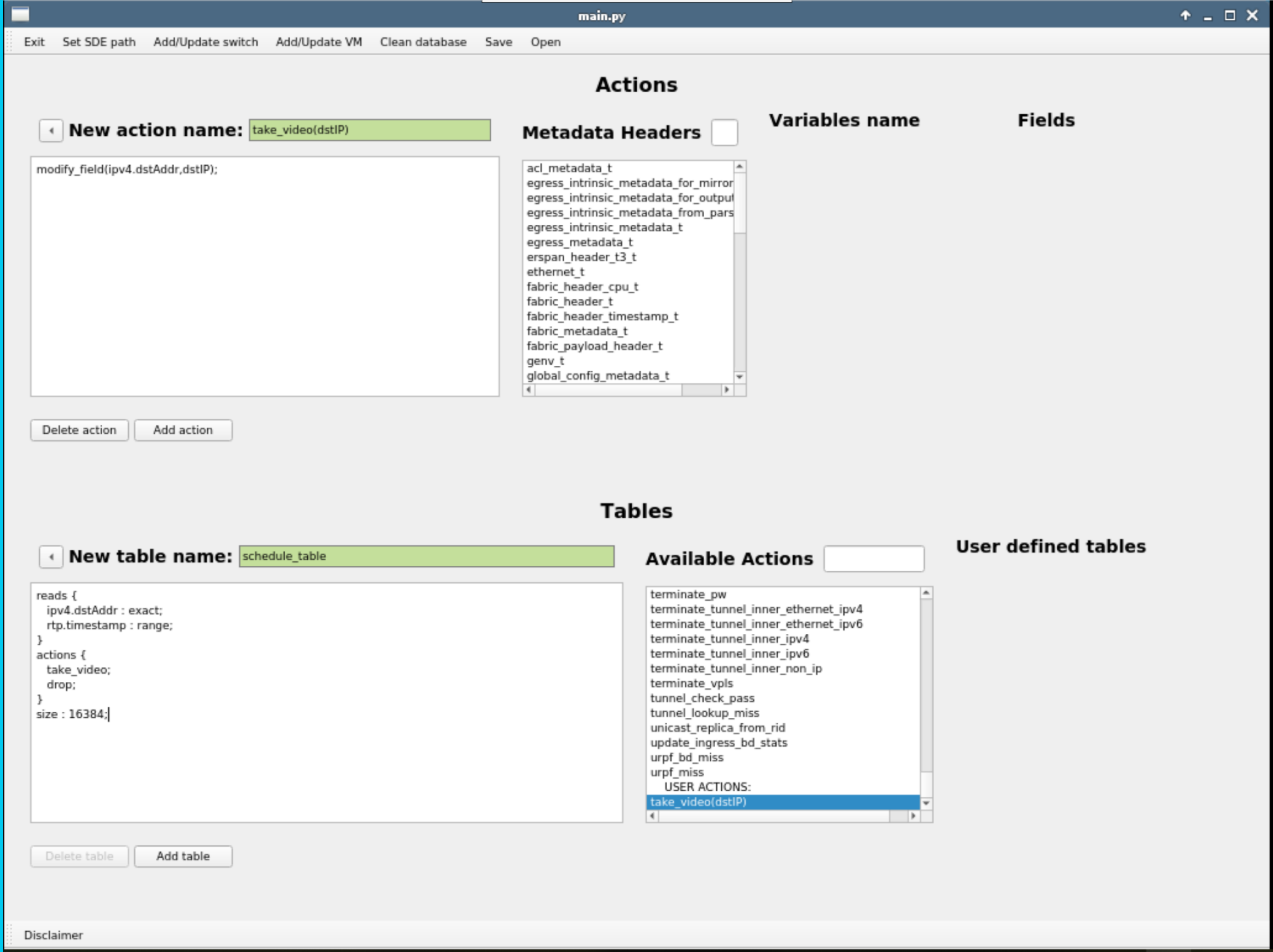
New table name:

Available Actions

- acl_deny
- acl_mirror
- acl_permit
- acl_redirect_ecmp
- acl_redirect_nexthop
- acl_stats_update
- compute_lkp_ipv4_hash
- compute_lkp_ipv6_hash
- compute_lkp_non_ip_hash
- compute_other_hashes
- copy_to_cpu
- copy_to_cpu_with_reason
- decap_genv_inner_ipv4
- decap_genv_inner_ipv6
- decap_genv_inner_non_ip

User defined tables

Adding a table



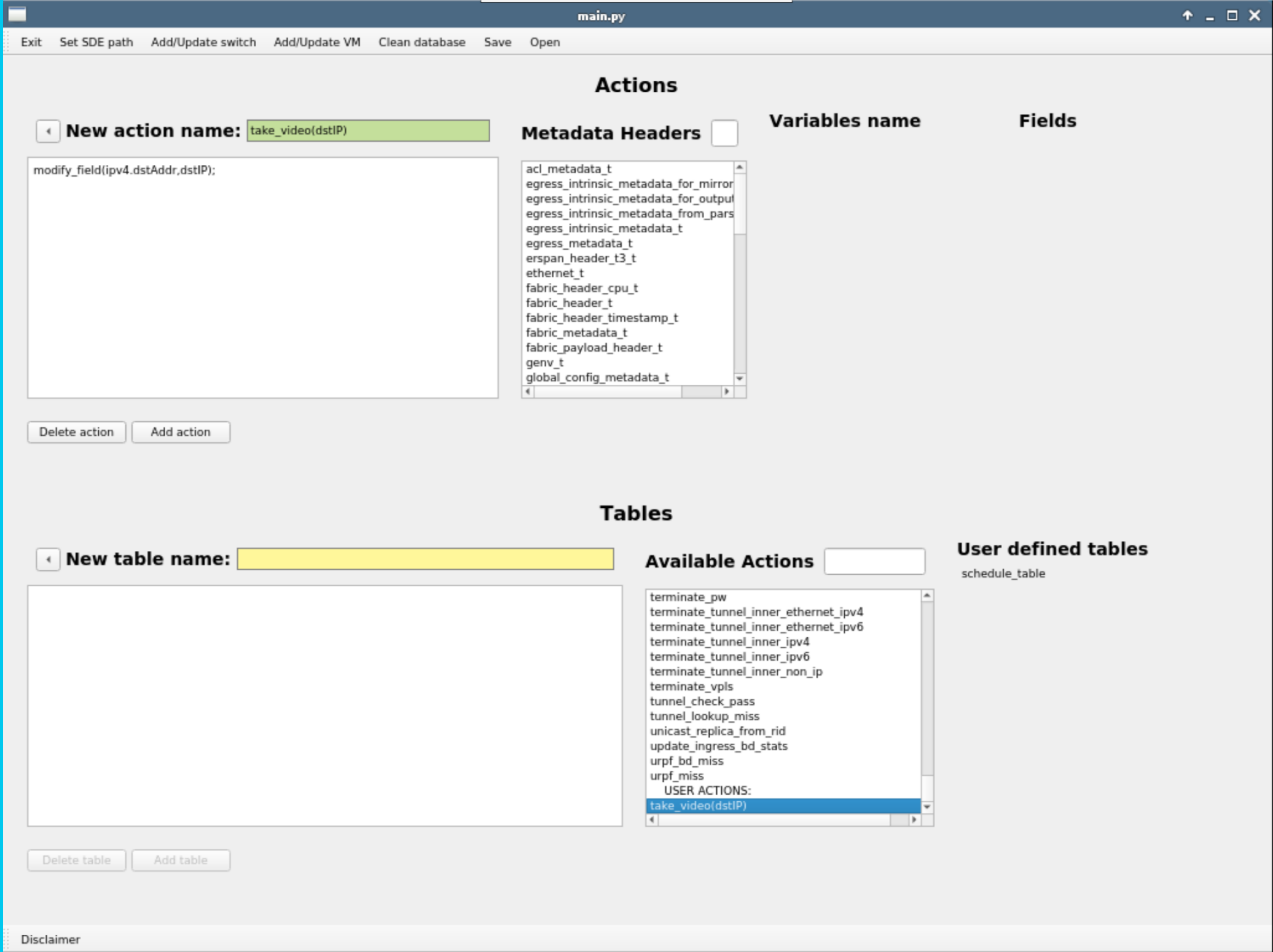
New action name: take_video(dstIP)

```
modify_field(ipv4.dstAddr,dstIP);
```

New table name: schedule_table

```
reads {
   ipv4.dstAddr : exact;
   rtp.timestamp : range;
}
actions {
   take_video;
   drop;
}
size : 16384;
```

New table available



Actions

New action name: take_video(dstIP)

```
modify_field(ipv4.dstAddr,dstIP);
```

Metadata Headers

acl_metadata_t
egress_intrinsic_metadata_for_mirror
egress_intrinsic_metadata_for_output
egress_intrinsic_metadata_from_pars
egress_intrinsic_metadata_t
egress_metadata_t
erspan_header_t3_t
ethernet_t
fabric_header_cpu_t
fabric_header_t
fabric_header_timestamp_t
fabric_metadata_t
fabric_payload_header_t
genv_t
global_config_metadata_t

Variables name

Fields

Tables

New table name:

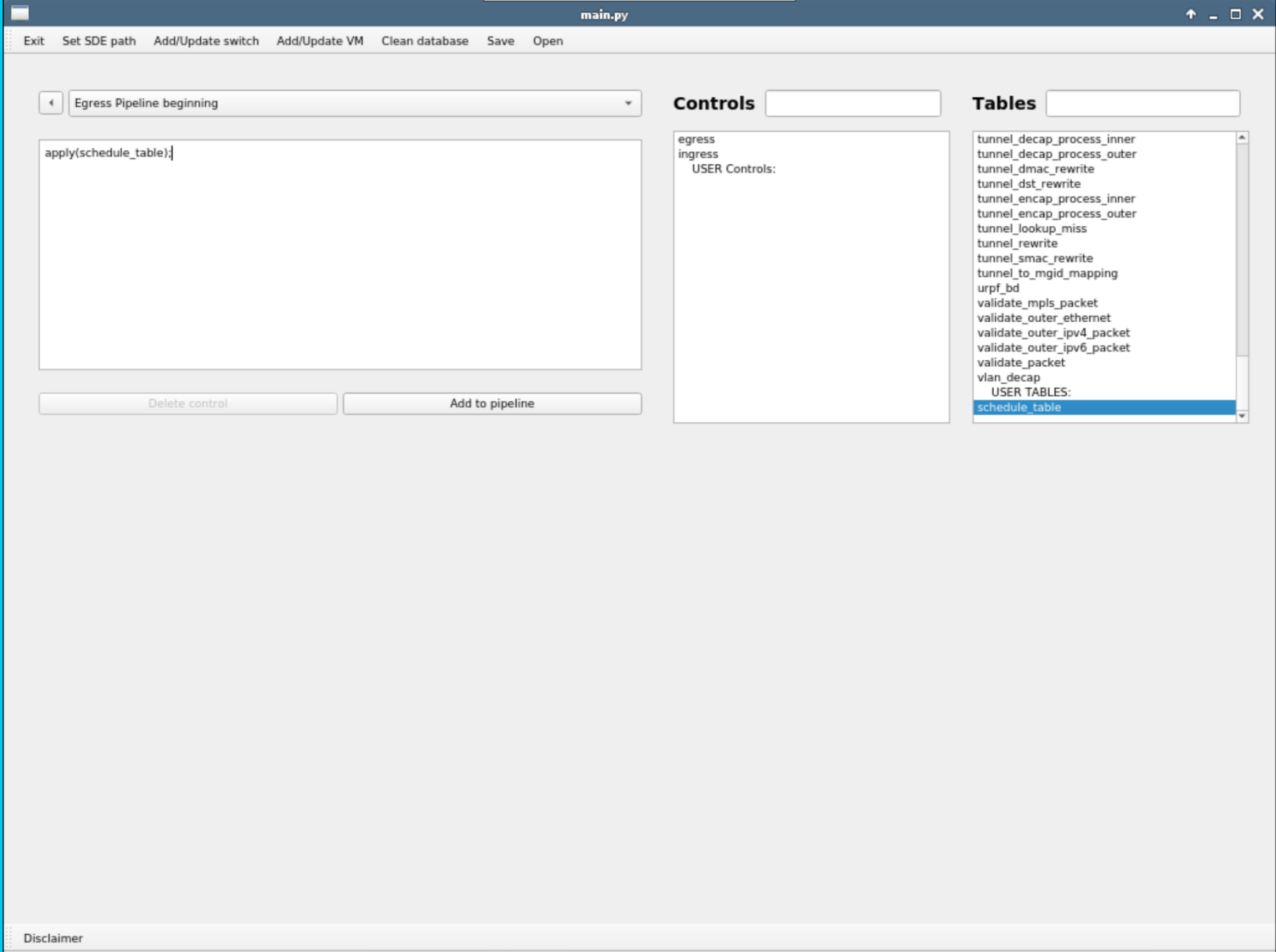
Available Actions

terminate_pw
terminate_tunnel_inner_ethernet_ipv4
terminate_tunnel_inner_ethernet_ipv6
terminate_tunnel_inner_ipv4
terminate_tunnel_inner_ipv6
terminate_tunnel_inner_non_ip
terminate_vpls
tunnel_check_pass
tunnel_lookup_miss
unicast_replica_from_rid
update_ingress_bd_stats
urpf_bd_miss
urpf_miss
USER ACTIONS:
take_video(dstIP)

User defined tables

schedule_table

Define control flow

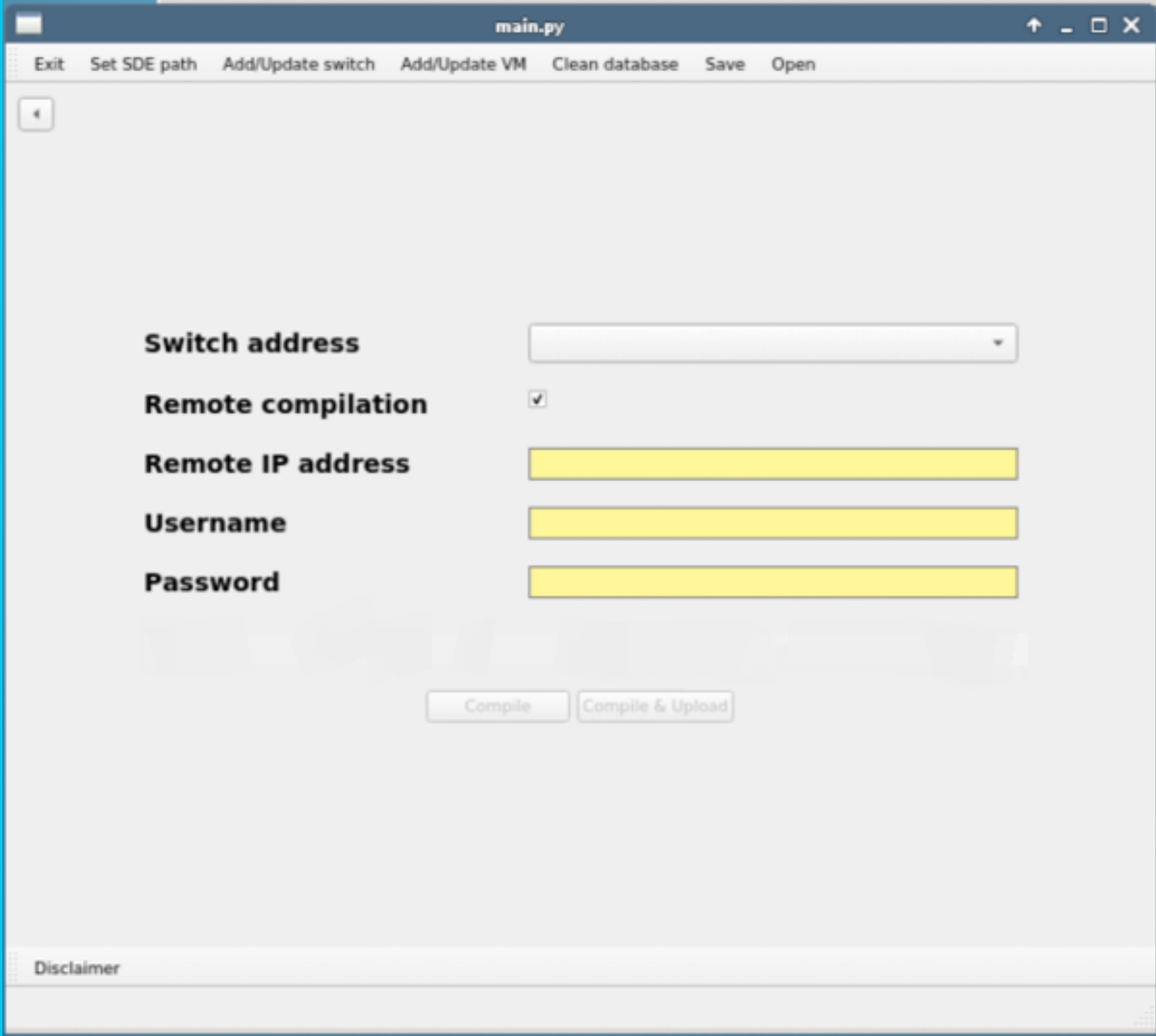


```
apply(schedule_table);
```

egress
ingress
USER Controls:

tunnel_decap_process_inner
tunnel_decap_process_outer
tunnel_dmac_rewrite
tunnel_dst_rewrite
tunnel_encap_process_inner
tunnel_encap_process_outer
tunnel_lookup_miss
tunnel_rewrite
tunnel_smac_rewrite
tunnel_to_mgid_mapping
urpf_bd
validate_mpls_packet
validate_outer_ethernet
validate_outer_ipv4_packet
validate_outer_ipv6_packet
validate_packet
vlan_decap
USER TABLES:
schedule_table

Compile and upload to switch



Switch address

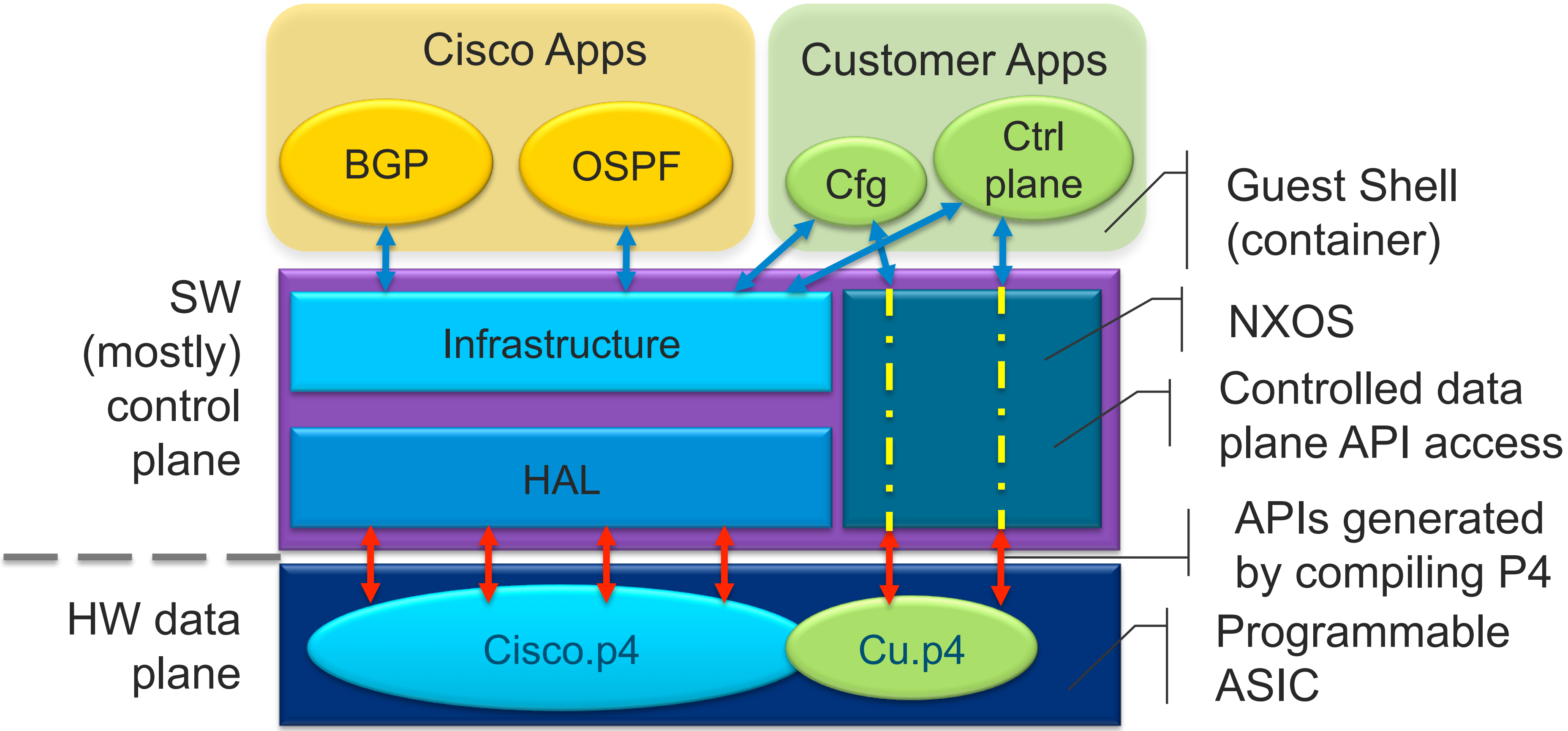
Remote compilation ☑

Remote IP address

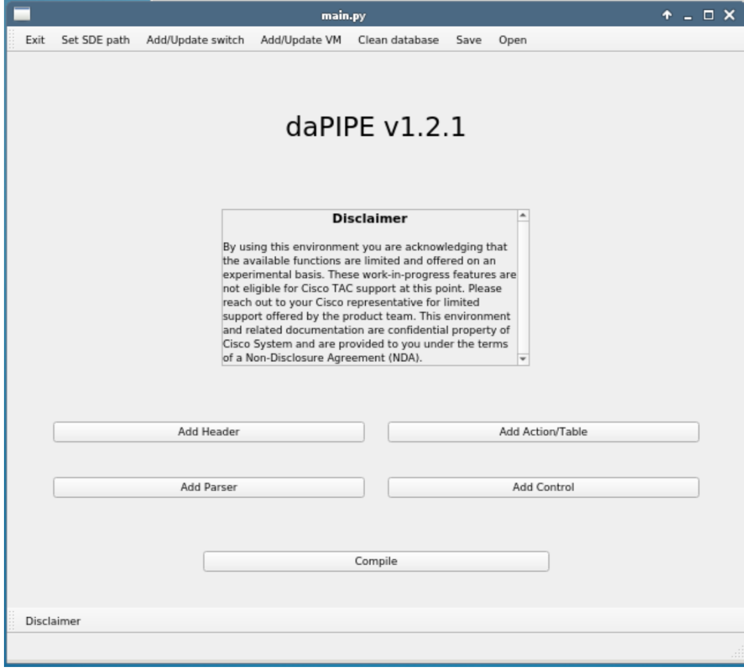
Username

Password

Control Plane



In summary



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- daPIPE enables incremental programming
  - Cisco NX34xxx so far
  - Not platform specific
    - Any platform, any NetOS
- Developer can focus just on new features
  - Does not need to work on common features
  - Can leverage existing functions
- No need to deal with the complexity of stock P4 code
- Constrained changes ensure stock feature and NetOS integrity
- It does not address any possible use case, but it addresses many

Interested in giving it a try?

Get in touch with me (mariobal@cisco.com) …

… and be willing to deal with the imperfections of something new