Programmable Dataplane using P4 Language

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Introduction

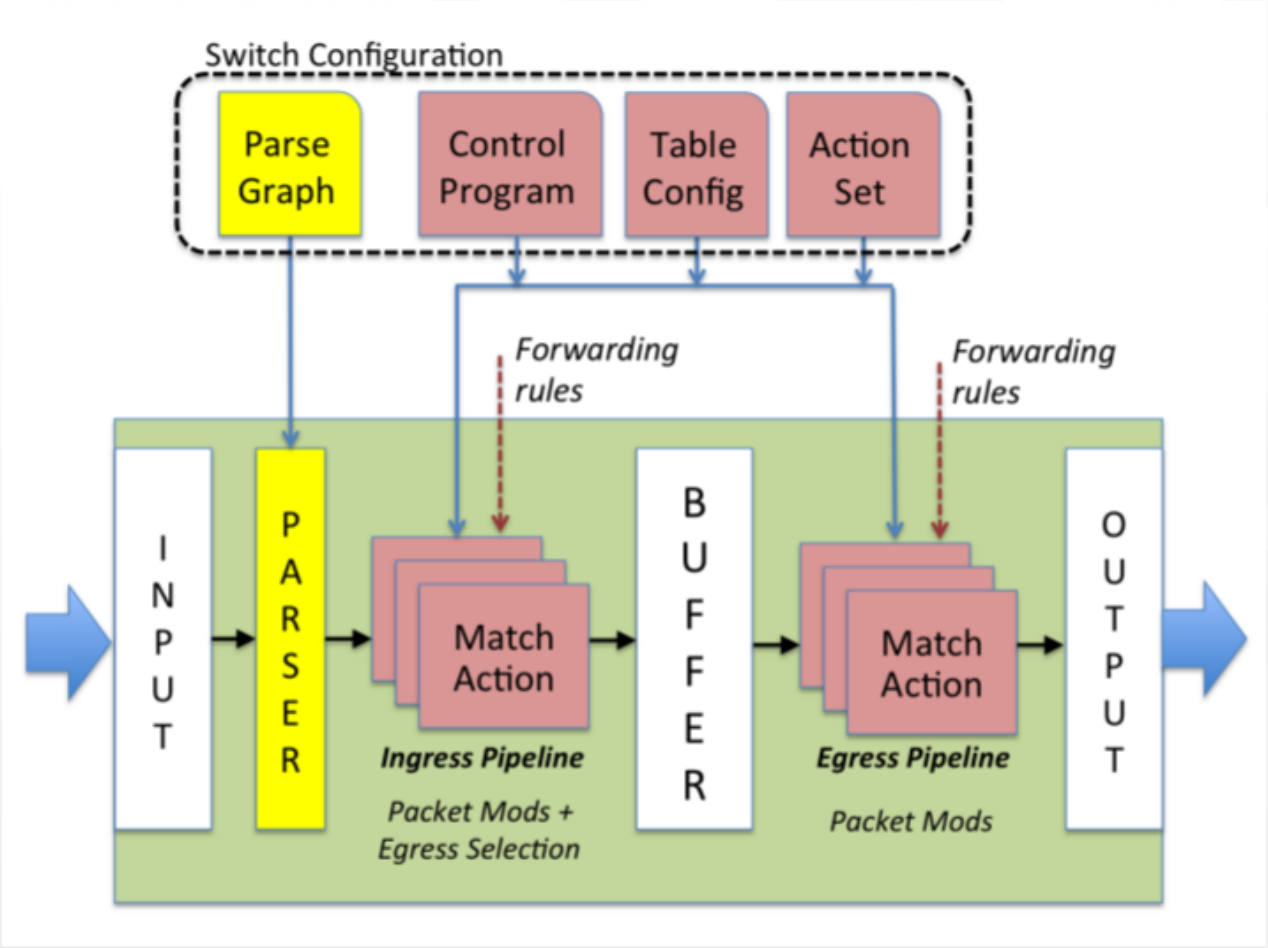
- P4 - Programming Protocol-Independent Packet Processors

- 3 major aspects
  - **Target independence**
  - **Protocol independence**
  - **Reconfigurability**

Key components

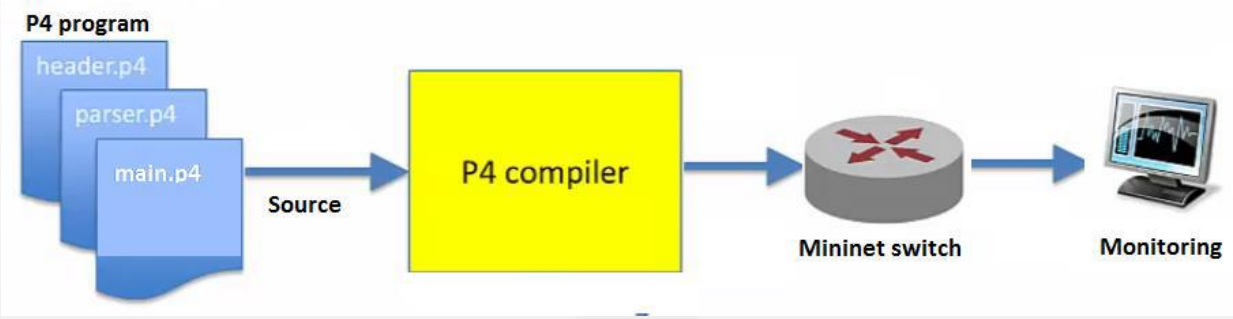
- **Headers**
  - describe sequence and structure of a series of fields.
- **Parsers**
  - specify how to identify headers and valid header sequences within packets.
- **Tables**
  - perform packet processing using fields for match.
- **Actions**
  - support for construction of complex actions from simpler protocol-independent primitives.
- **Control programs**
  - determine the order of match + action tables that are applied to a packet.

Abstract forwarding model



Project Idea

- Design packet encapsulate/de-capsulate modules that can process packet headers and perform the following tasks applications and controllers
  - Identify video streams from/to a streaming server
  - Identify YouTube streams
  - Identify OpenSSL flows
  - Record and report statistics regarding the above flows

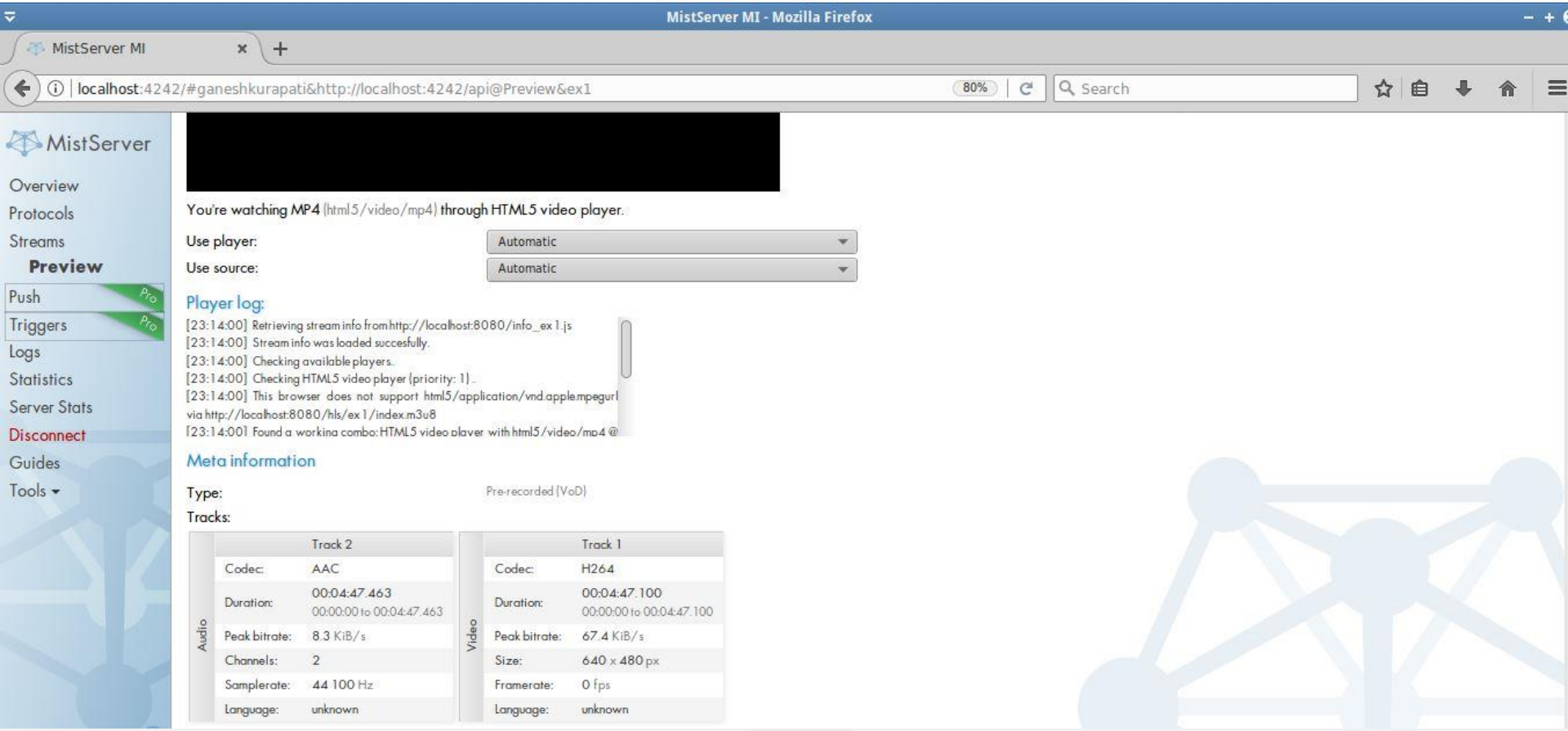


Tools and programs

Mist streaming server

- Open-source multimedia streaming server
- Supported formats and protocols : HLS, HDS, Smooth Streaming, RTMP, RTSP, MP3, FLV
- Works on multiple platforms and provides web interface for configuration management

Mist server web interface



UMASS LOWELL

TCP REPLAY

TCP REWRITE

- Provides packet editing functionality for pcap files
- Rewriting Source & Destination MAC addresses

  tcprewrite --enet-dmac=mac1 --enet-smac=mac2 --infile=input.pcap --outfile=output.pcap
- Modify Source and destination IP Addresses

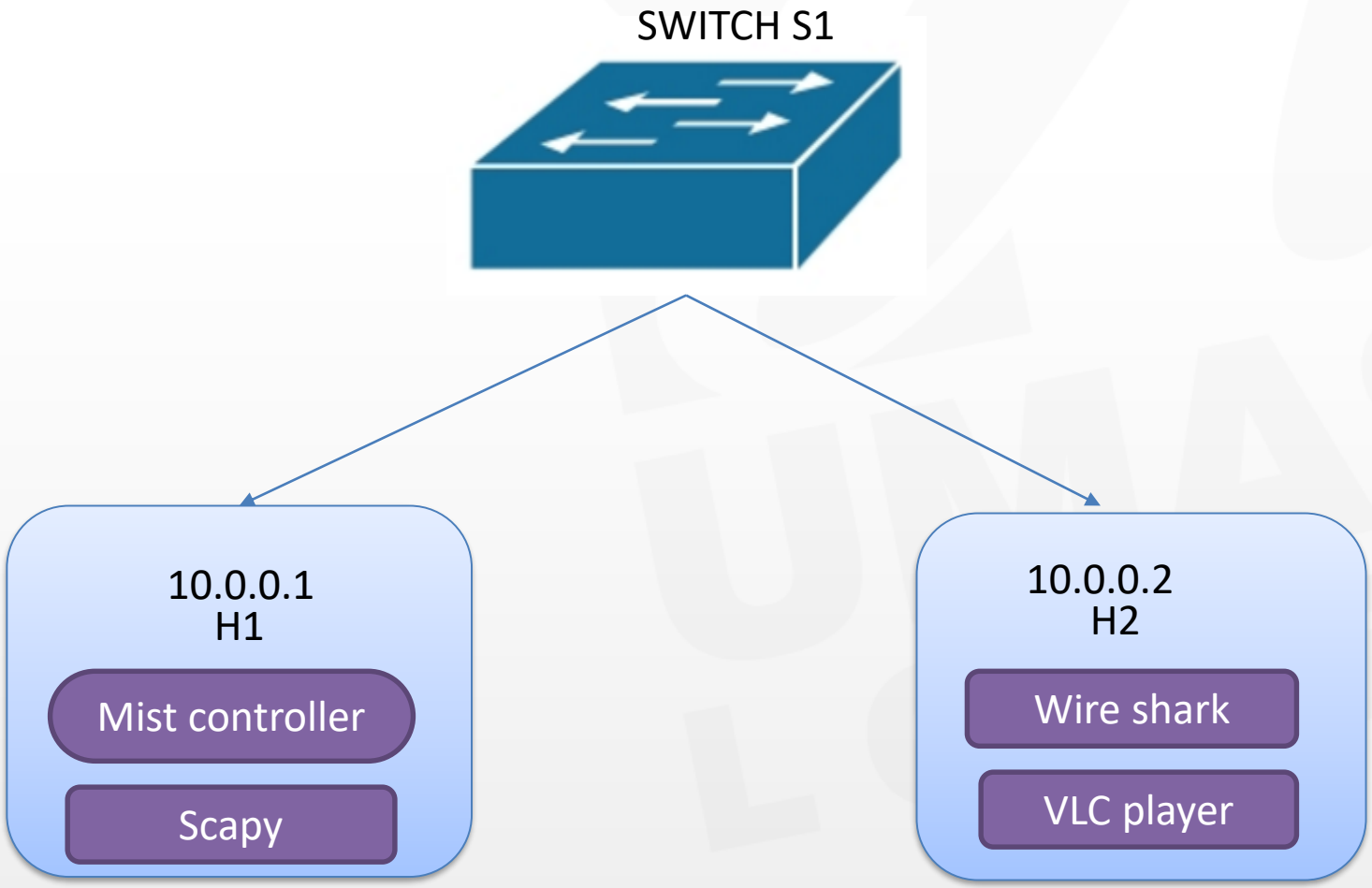
  tcprewrite --endpoints=ipv4-1:ipv4-2 --cachefile=example.cache --infile=example.pcap --outfile=new.pcap

SCAPY

- Forge or decode packets of a wide number of protocols, send them on the wire, capture them, match requests and replies
- Replay modified packets and send them to the switch s1
- Packets are sent using the command

  sendp(rdpcap("/tmp/pcapfile"))

Environment setup



DEMO

P4 Program

headers.p4 and parser.p4

```
header_type tcp_t {
    fields {
        srcPort : 16;
        dstPort : 16;
        seqNo : 32;
        ackNo : 32;
        dataOffset : 4;
        res : 4;
        flags : 8;
        window : 16;
        checksum : 16;
        urgentPtr : 16;
    }
}

header_type udp_t {
    fields {
        srcPort : 16;
        dstPort : 16;
        length_ : 16;
        checksum : 16;
    }
}
```

```
#define IP_PROTOCOLS_TCP 6
#define IP_PROTOCOLS_UDP 17

parser parse_ipv4 {
    extract(ipv4);
    return select(latest.protocol) {
        IP_PROTOCOLS_TCP : parse_tcp;
        IP_PROTOCOLS_UDP : parse_udp;
        default: ingress;
    }
}

header tcp_t tcp;

parser parse_tcp {
    extract(tcp);
    return ingress;
}

header udp_t udp;

parser parse_udp {
    extract(udp);
    return ingress;
}
```

P4 Program

Counters

```
action on_miss() {
}

counter c_quic {
    type: packets;
    instance_count: 32;
}

action count_quic(){
    count(c_quic, 1);
}

counter c_ssl {
    type: packets;
    instance_count: 32;
}

action count_ssl(){
    count(c_ssl, 1);
}
```

```
counter c_rtmp {
    type: packets;
    instance_count: 32;
}

action count_rtmp(){
    count(c_rtmp, 1);
}
```

P4 Program

Tables

```
table quic_count_src {
    reads {
        udp.srcPort : exact;
    }
    actions {
        on_miss;
        count_quic;
            _drop;
    }
    size : 256;
}

table quic_count_dst {
    reads {
        udp.dstPort : exact;
    }
    actions {
        on_miss;
        count_quic;
            _drop;
    }
    size : 256;
}
```

```
table ssl_rtmp_count_src {
    reads {
        tcp.srcPort : exact;
    }
    actions {
        on_miss;
        count_ssl;
        count_rtmp;
            _drop;
    }
    size: 256;
}

table ssl_rtmp_count_dst {
    reads {
        tcp.dstPort : exact;
    }
    actions {
        on_miss;
        count_rtmp;
            _drop;
    }
    size: 256;
}
```

P4 Program

ingress and egress

```
control ingress {
    apply(ipv4_lpm);
    apply(forward);
    if(valid(udp)){
    apply(quic_count_src){
        on_miss{
         apply(quic_count_dst);
       }
     }
    }//if
    if(valid(tcp)){
    apply(ssl_rtmp_count_src){
       on_miss{
         apply(ssl_rtmp_count_dst);
       }
     }
    }//if
}

control egress {
    apply(send_frame);
}
```

Add or Delete Table Entries

Bash files

```
python ../../cli/pd_cli.py -p simple_router -i p4_pd_rpc.simple_router -s $PWD/tests/pd_thrift:
$PWD/../../testutils -m "add_entry quic_count_src 443 count_quic" -c localhost:22222
python ../../cli/pd_cli.py -p simple_router -i p4_pd_rpc.simple_router -s $PWD/tests/pd_thrift:
$PWD/../../testutils -m "add_entry quic_count_dst 443 count_quic" -c localhost:22222
```

```
python ../../cli/pd_cli.py -p simple_router -i p4_pd_rpc.simple_router -s $PWD/tests/pd_thrift:
$PWD/../../testutils -m "delete_entry quic_count_src 0" -c localhost:22222
python ../../cli/pd_cli.py -p simple_router -i p4_pd_rpc.simple_router -s $PWD/tests/pd_thrift:
$PWD/../../testutils -m "delete_entry quic_count_dst 0" -c localhost:22222
```

```
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$PWD/../../testutils -m "add_entry quic_count_dst 443 _drop" -c localhost:22222
```

Conclusion

- Successful implementation of program using P4 language to parse and identify specific type of packets, depending on which further actions can be defined.

- Future work
  - The counter data to be fetched for traffic analysis and implement reporting.
  - Contextual routing.

References

- https://en.wikipedia.org/wiki/P4_(programming_language)
- P4: Programming Protocol-Independent Packet Processors - P. Bosshart, D. Daly, G. Gibb, M. Izzard, N. McKeown, J. Rexford, C. Schlesinger, D. Talayco, A. Vahdat, G. Varghese, D. Walker; CCR July 2014
- http://p4.org/