CLICK

A NEW PROGRAMMING LANGUAGE FOR DEVELOPING SOFTWARE ROUTERS

Under the Guidance of

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MTech Seminar
Presented By

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Acknowledgment

The graphs and figures are taken from Eddie Kohler's PhD thesis.

Network Diagram is created on "http://www.lovelycharts.com/"

Contents

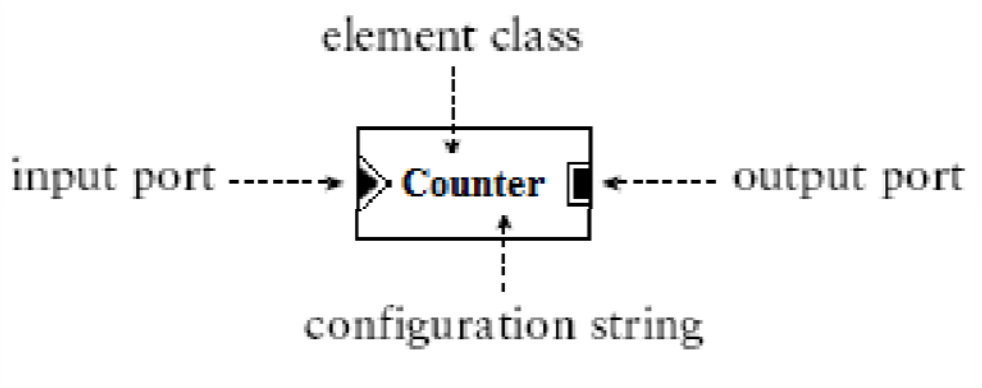
Introduction

- History - “Routers”
  - Packet forwarders => firewall, load balancer
  - Closed, Static, Inflexible Design.

- Solution – ***“Click”***
  - Simplicity
  - No. of lines code
  - Solution of problems simple then normal

Architecture

- Modular design
- Directed graph
  - Element Class
  - Ports
    - Push
    - Pull
    - Agnostic
  - Handlers



Click – The Programming Language

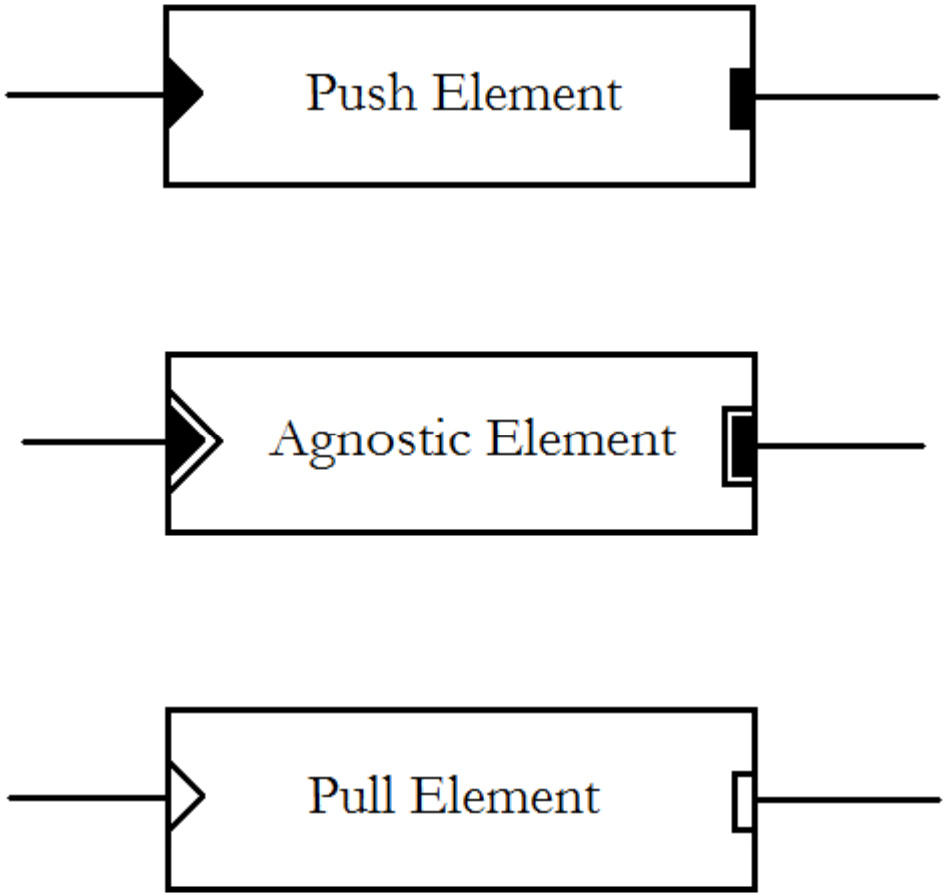
- Declarative Language
- Written in C++
- Syntax

```
h :: Hub
q :: Queue
FromDevice(eth0) -> [0]h;
FromDevice(eth1) -> [1]h;
h[0] -> q;
h[1] -> q;
q -> toDevice(eth0);
q -> toDevice(eth1);
```

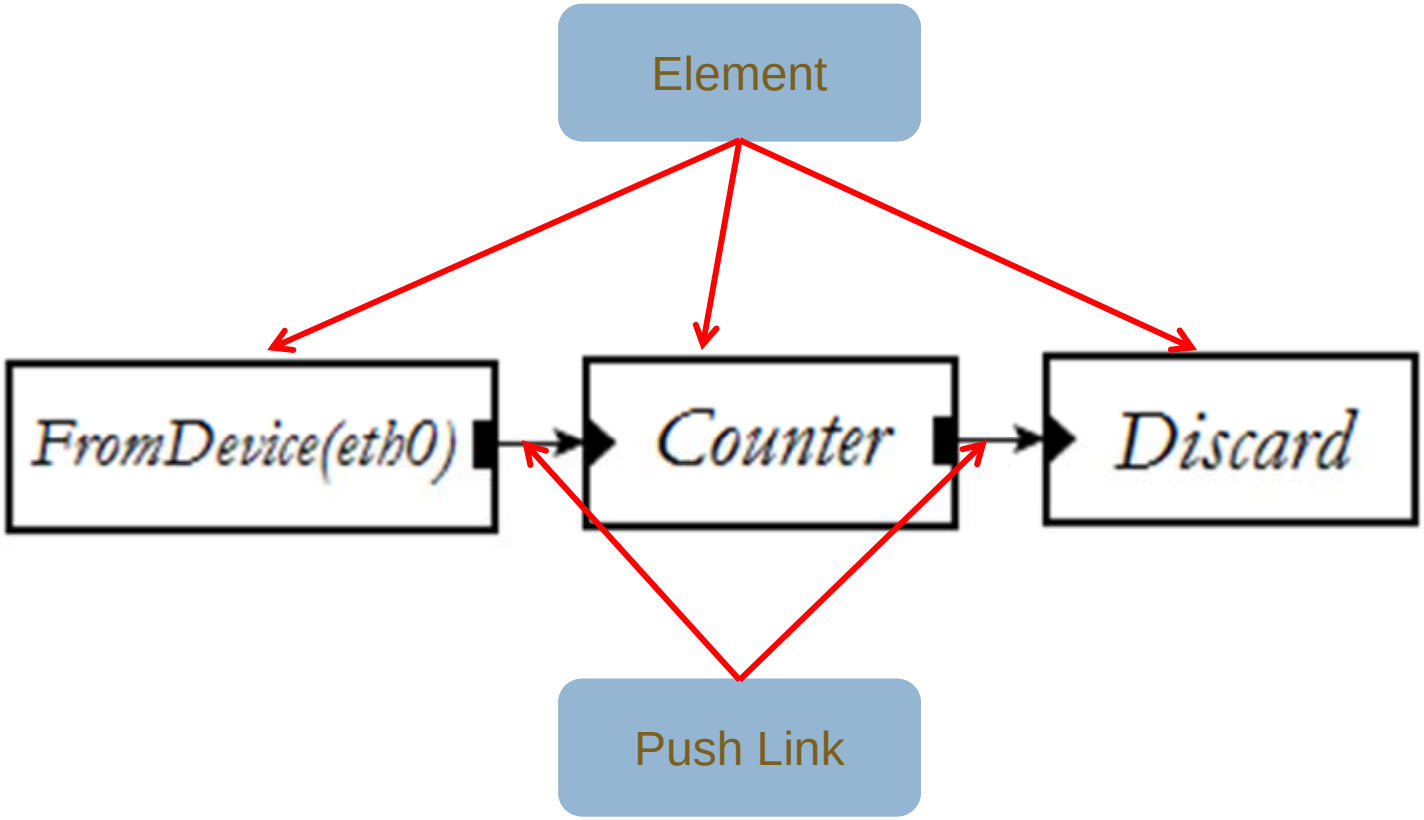
- Examples

```
----------------------- C++ -----------------------
class Hub : public Element { public:
    Hub();
    ~Hub();
    const char *class_name() const
      { return "Hub"; }
    const char *port_count() const
      { return "-/="; }
    const char *processing() const
      { return PUSH; }
    const char *flow_code() const
      { return "#/[^#]"; }
    void push(int port, Packet* p);
};
```

Symbols and Semantics



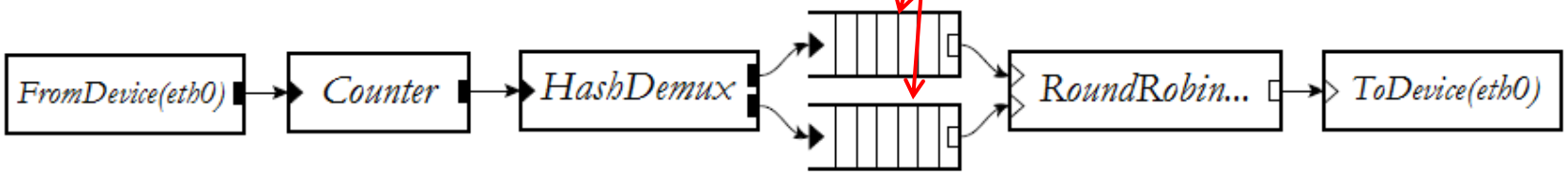
Example – 1



Simple Router

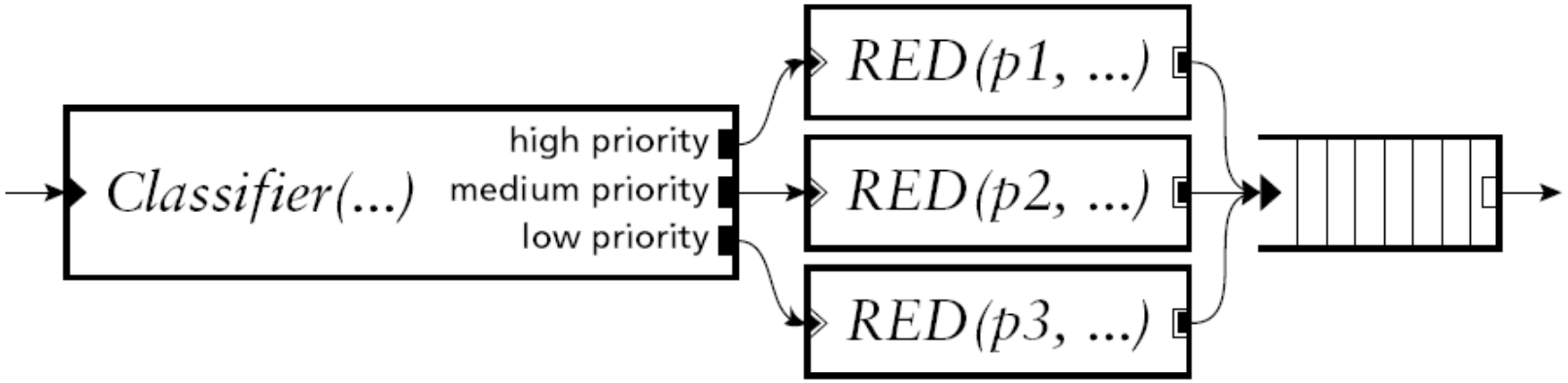
Example – 2

Queue is the element having both (PUSH and PULL) types of ports.



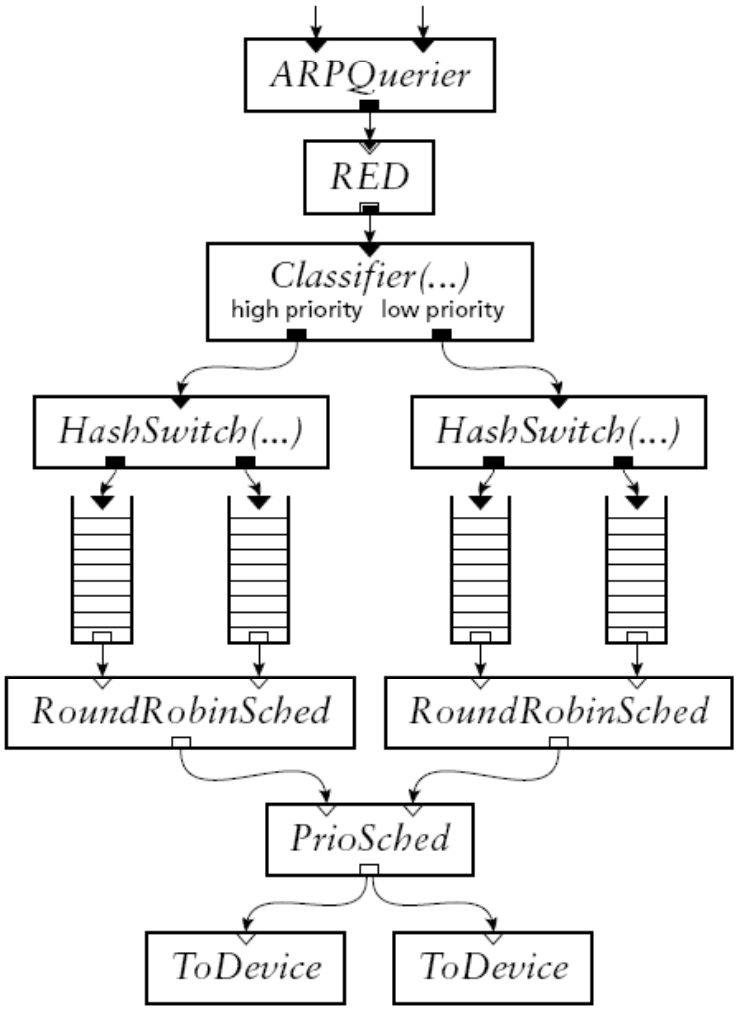
Implementing Stochastic Fairness Queuing

Example – 3



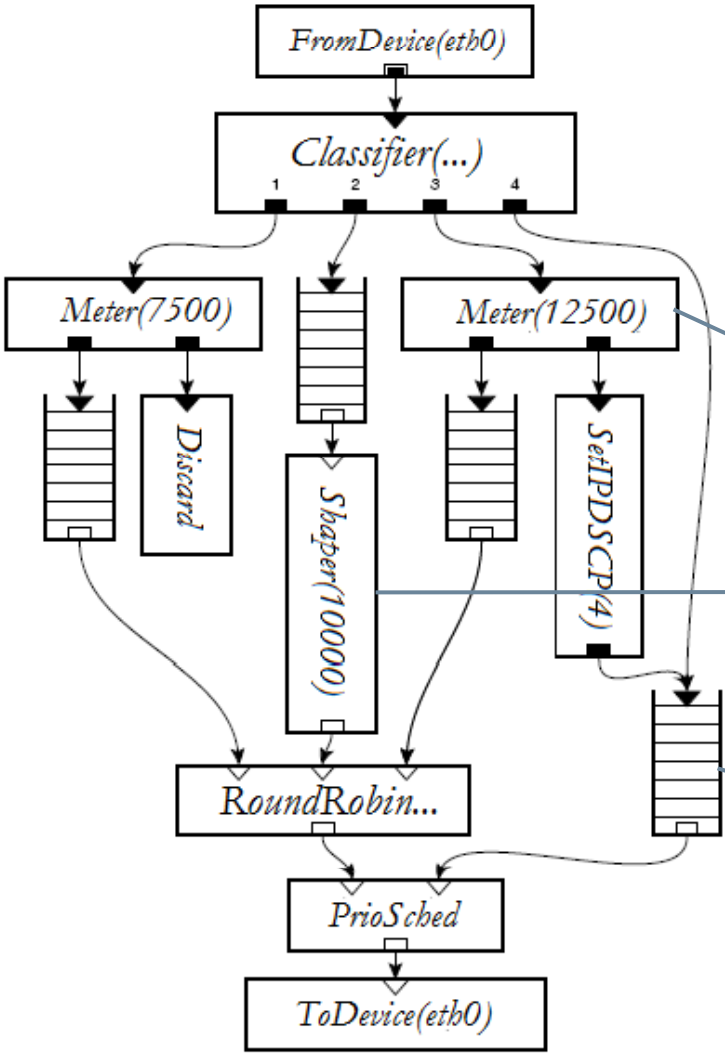
Implementing RED

Example – 4



Implementing Priority flow on the Stochastic Fairness Queuing with dropping mechanism

Example – 5



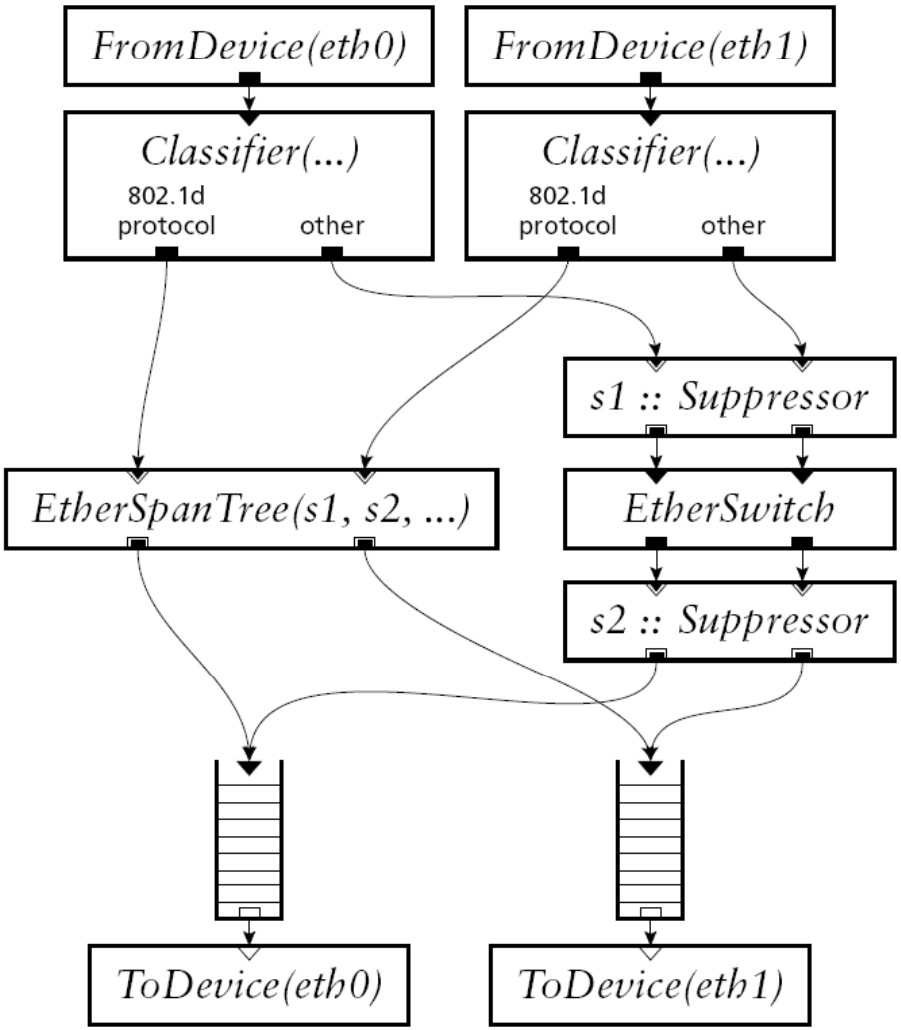
Differentiated Services Algorithm

Will send12,500 packets/second on its first output port other on second output port.

Will pull10,000 packets/second queue will determine which packets to drop, if busty flow.

Best effort flow queue.

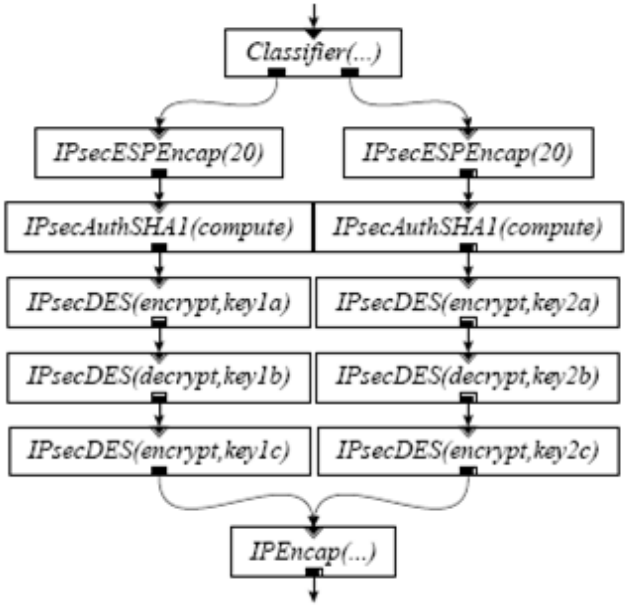
Example – 6



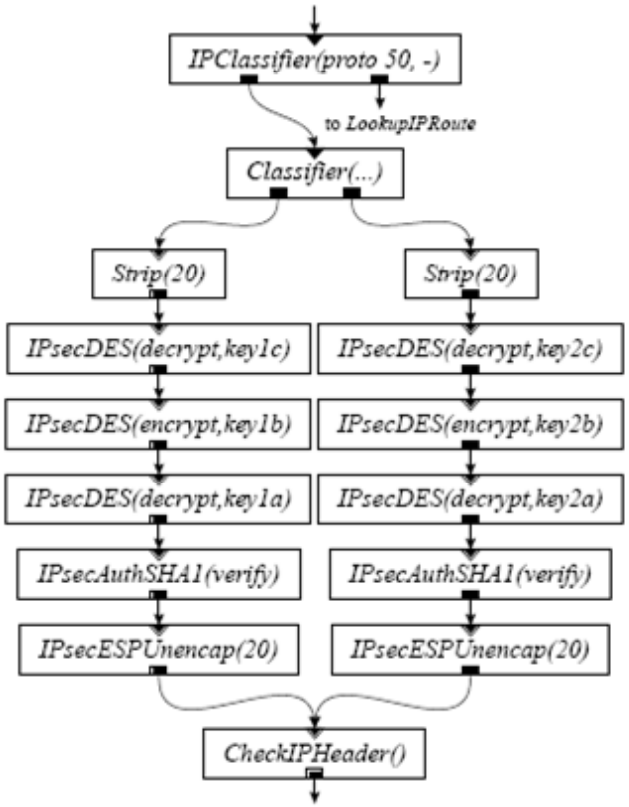
Ethernet Switch

This works as a 802.1d standard learning bridge between two networks connected to eth0 and eth1 ports.

Example – 7



IPSec VPN Tunnel Encryption configuration.



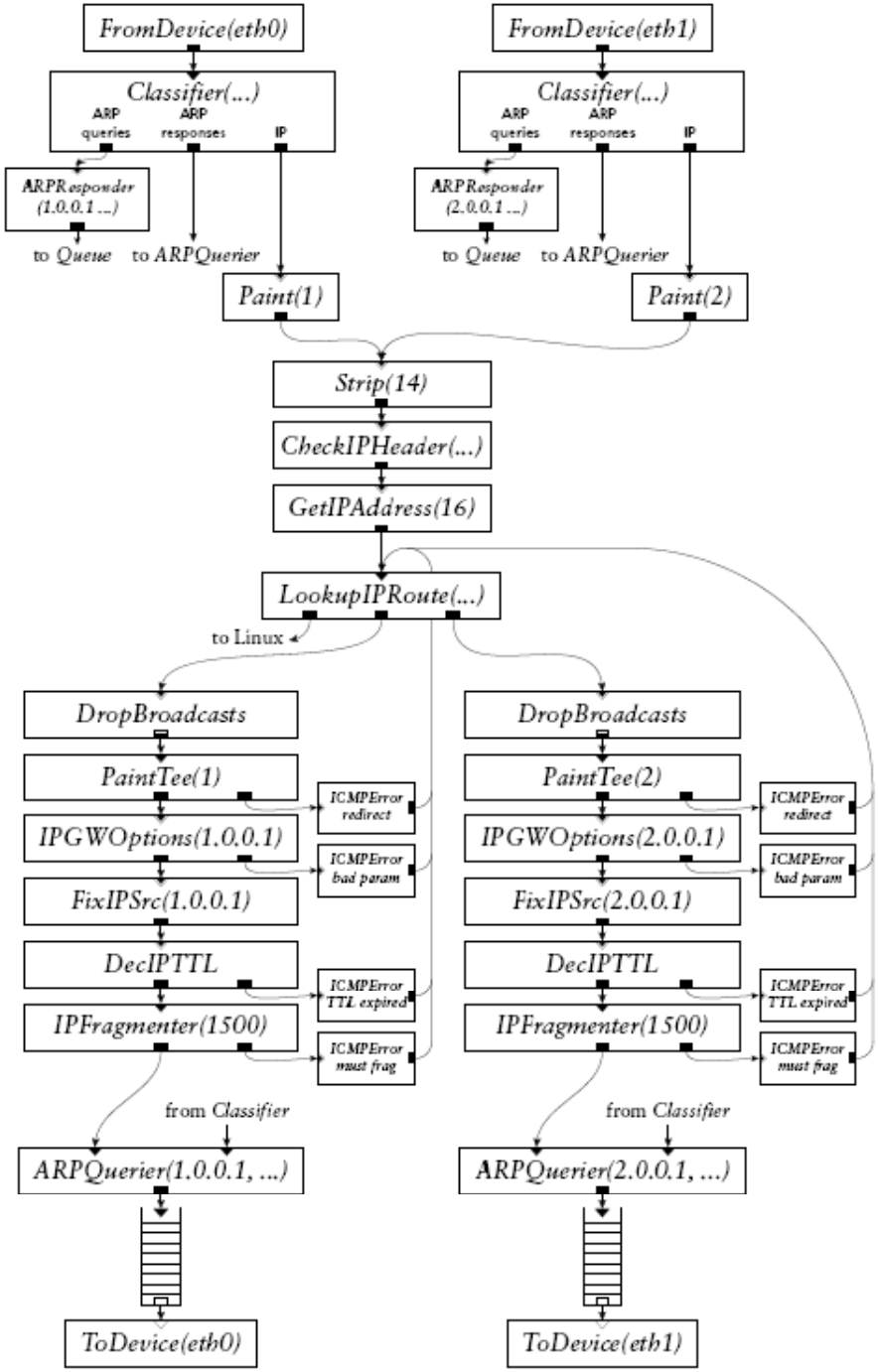
IPSec VPN Tunnel Decryption configuration.

IPSec Implementation

Figure Source [4]

Example – 8

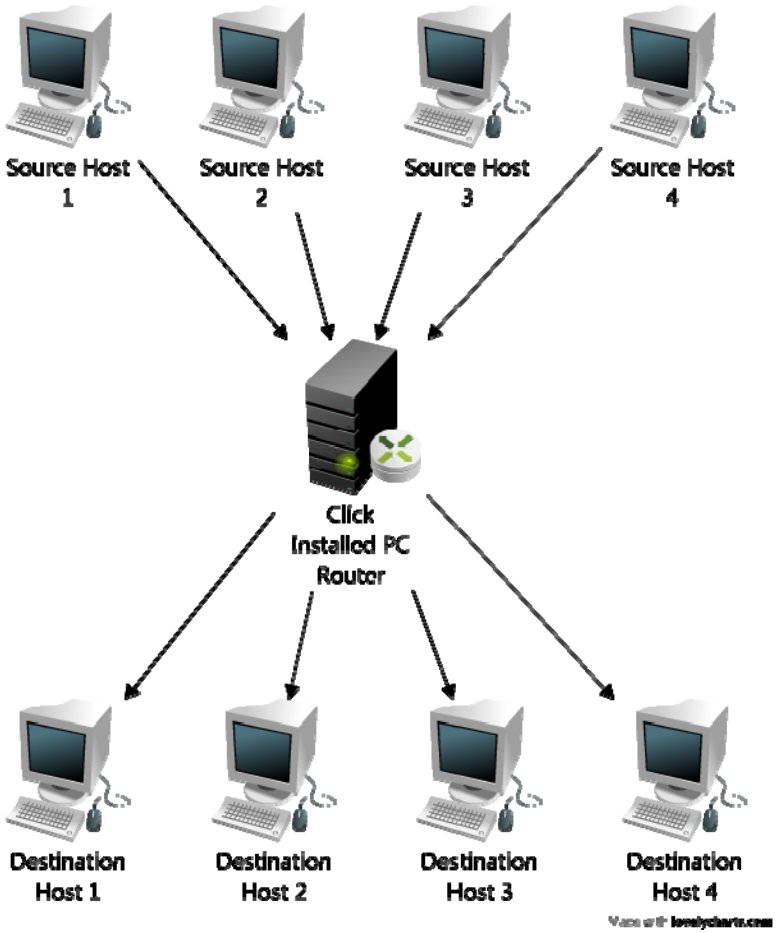
Full fledged
IP Router



Evaluation

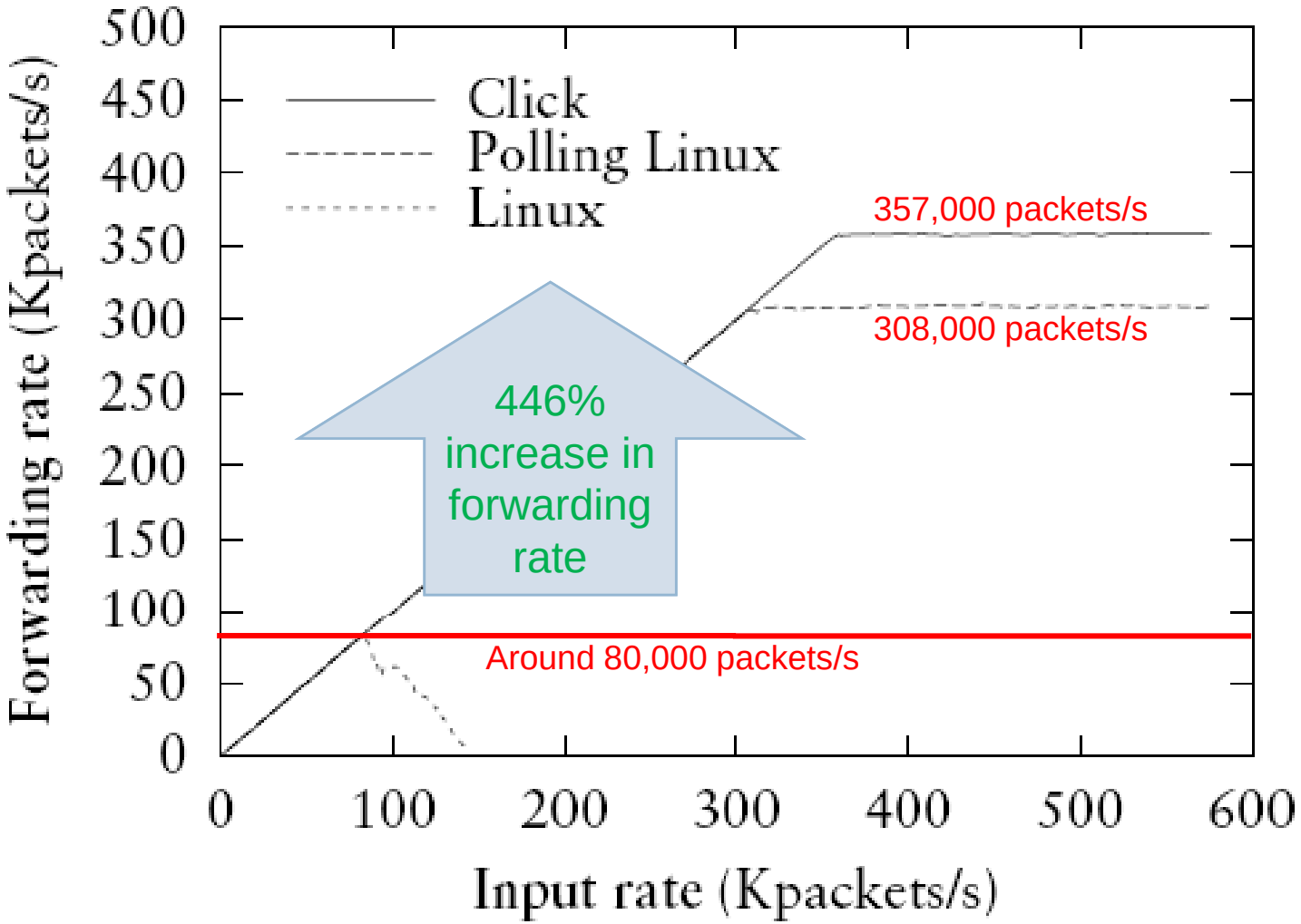
- Forwarding path
- Performance of the **“*Click*”** diffserv configuration
- Comparison of IP router and non-IP router created with click
- CPU time breakdown

Experimental Setup

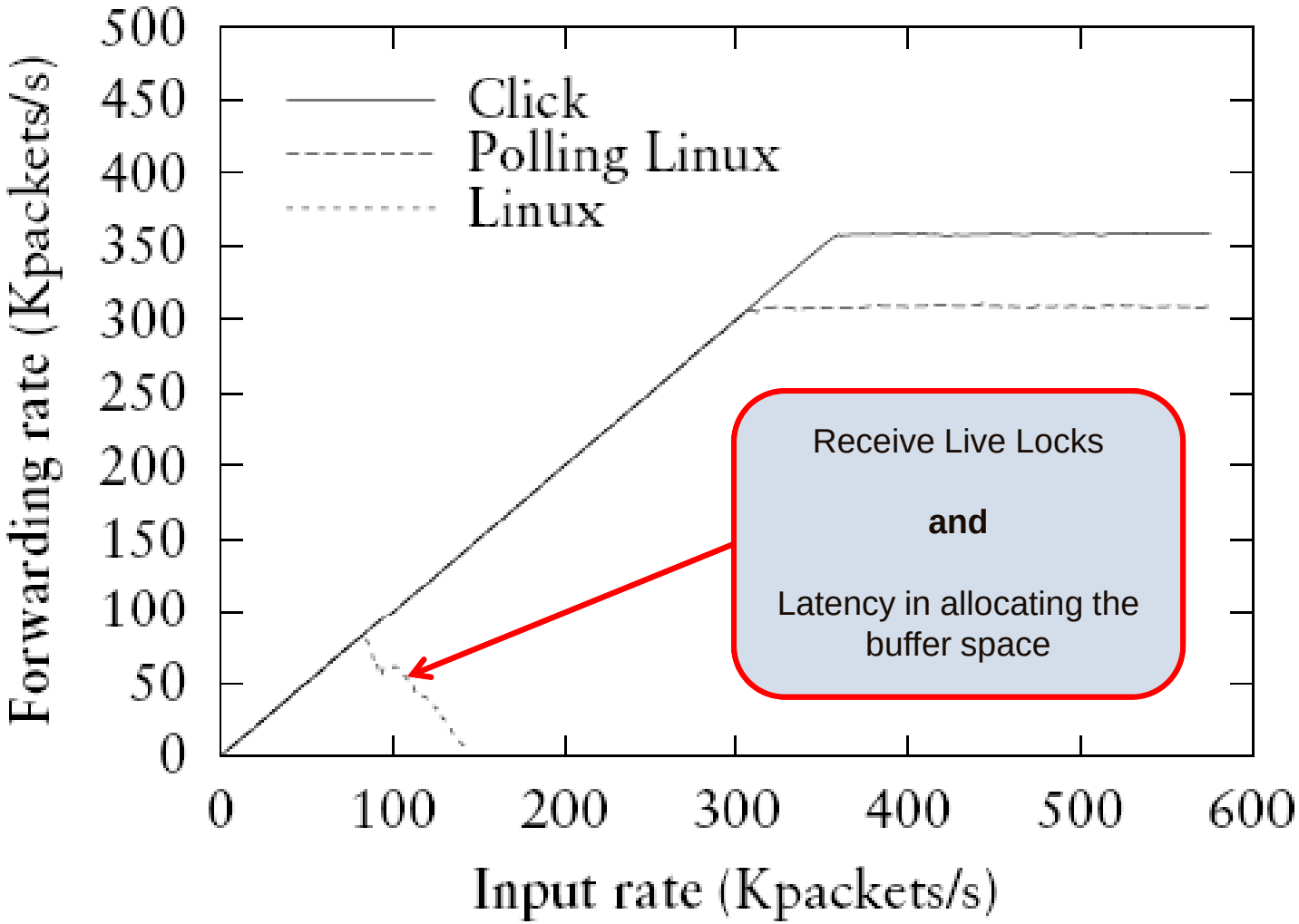


- All are having DEC 21140 Tulip 100 Mbit/s PCI Ethernet Controllers.
- Router Host
  - 700 MHz Intel Pentium III CPU
  - Eight Ethernet Controllers are on multi-port cards split across the motherboard's two independent PCI buses.
- Source Hosts
  - 733 MHz Pentium III CPUs
  - Generates the 64-byte packets per second of UDP flow.
- Destination Hosts
  - 200 MHz Pentium Pro CPUs
  - Counts and Discards the packets.

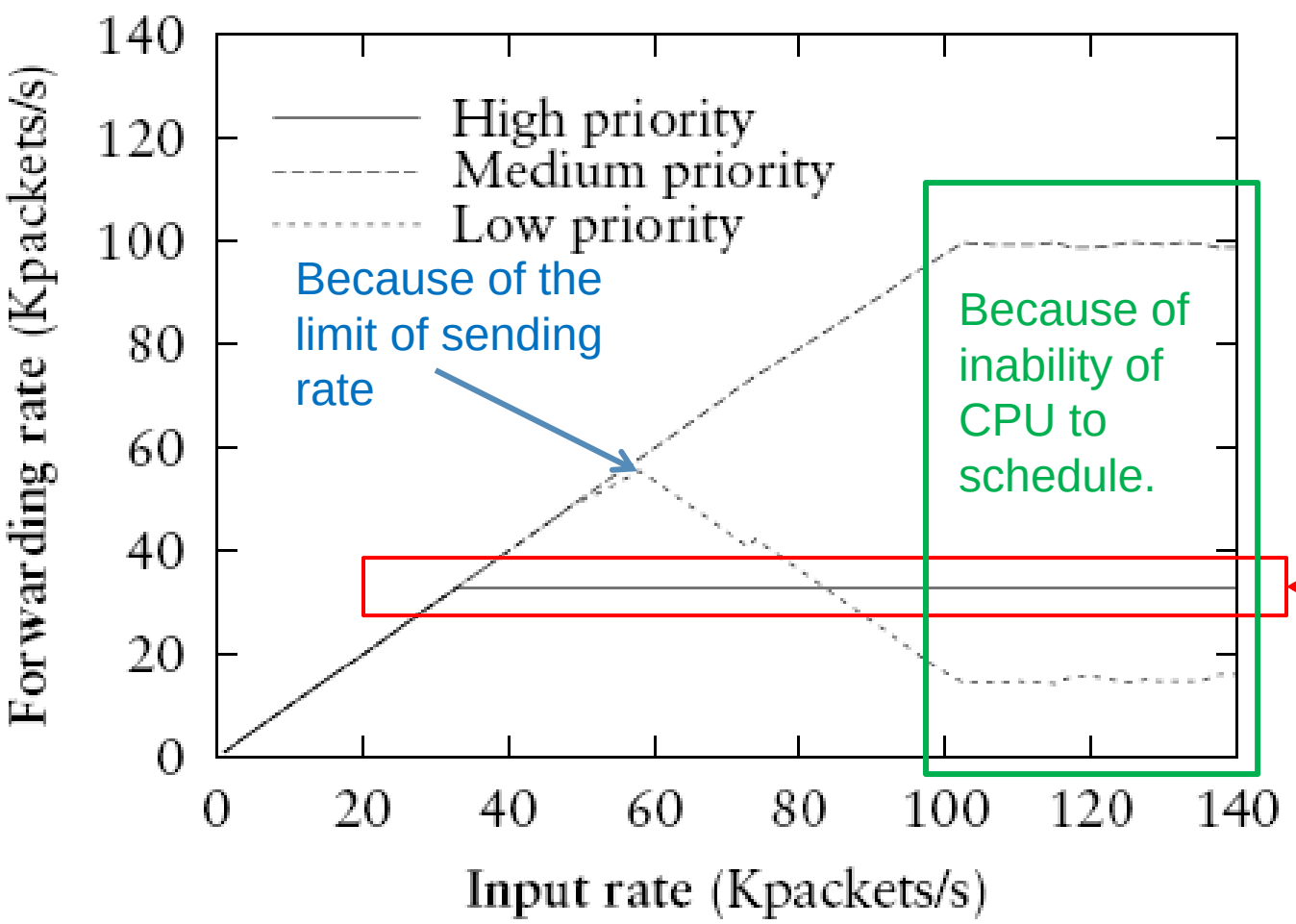
Forwarding Path

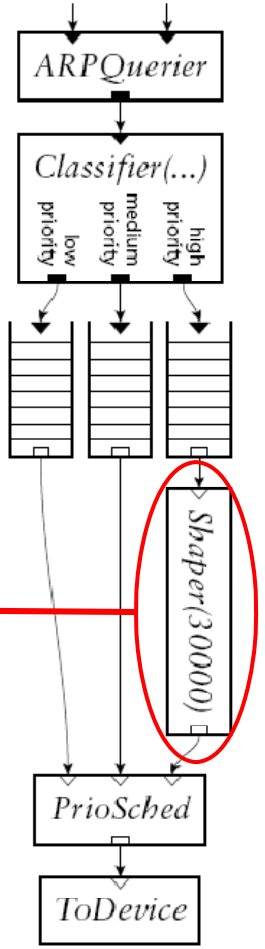


Forwarding Path

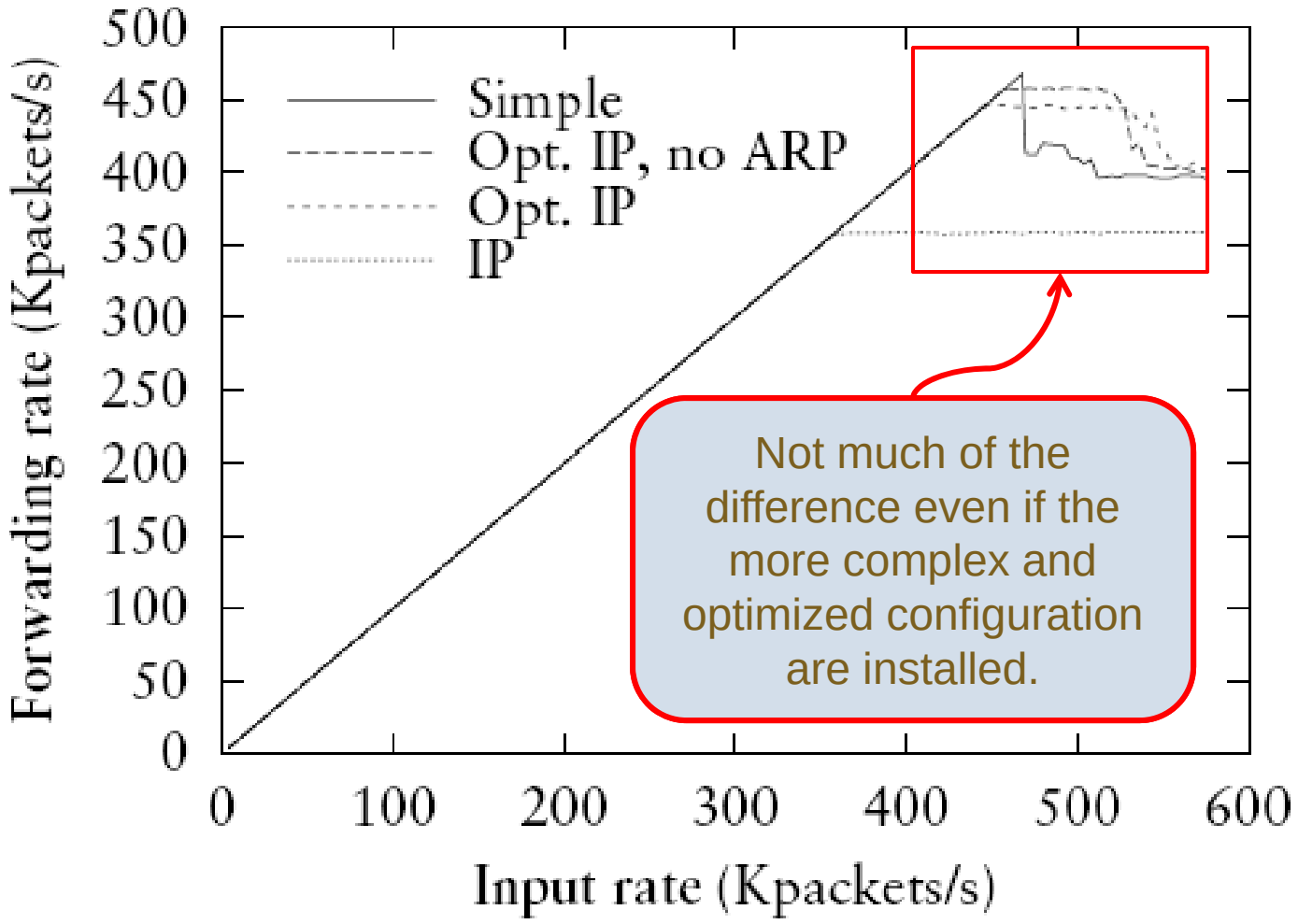


Performance of the Click diffserv configuration

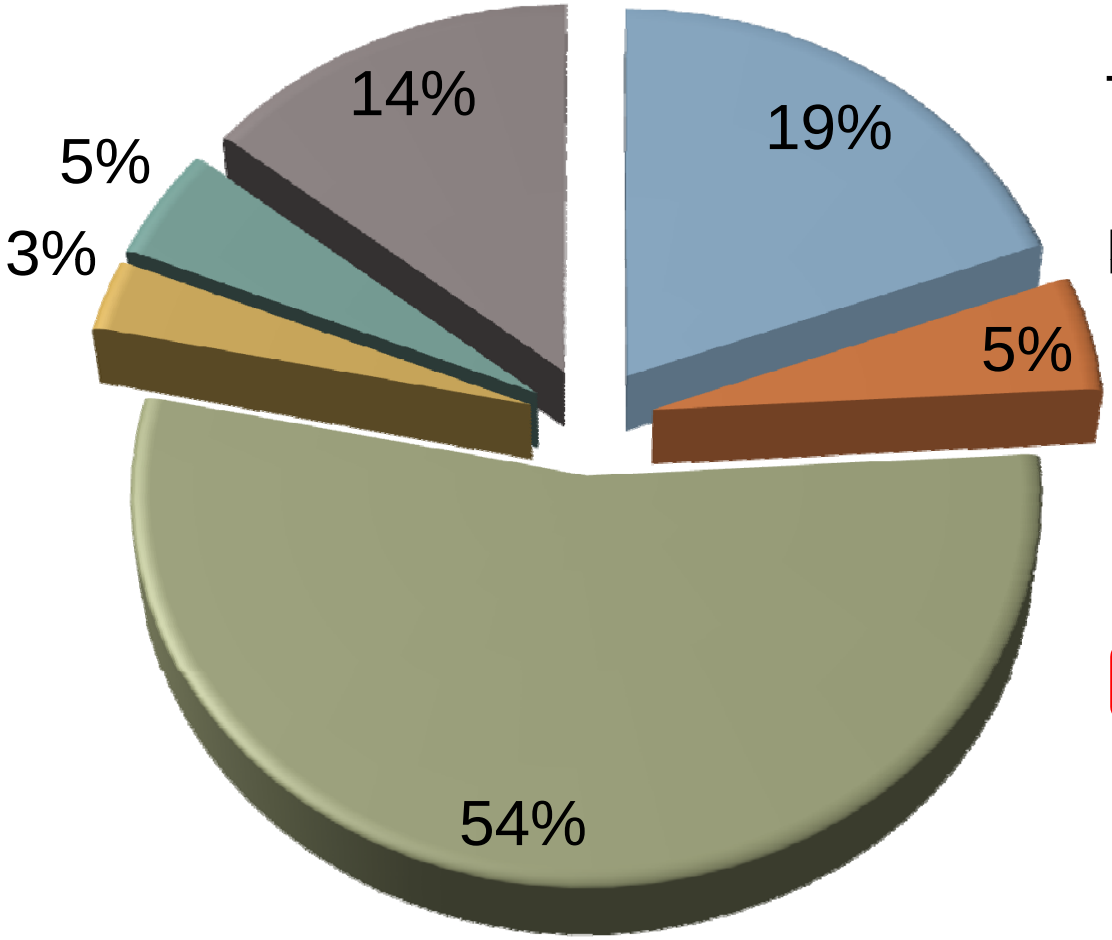




Comparison of IP router and non-IP router created with click



CPU Time Breakdown



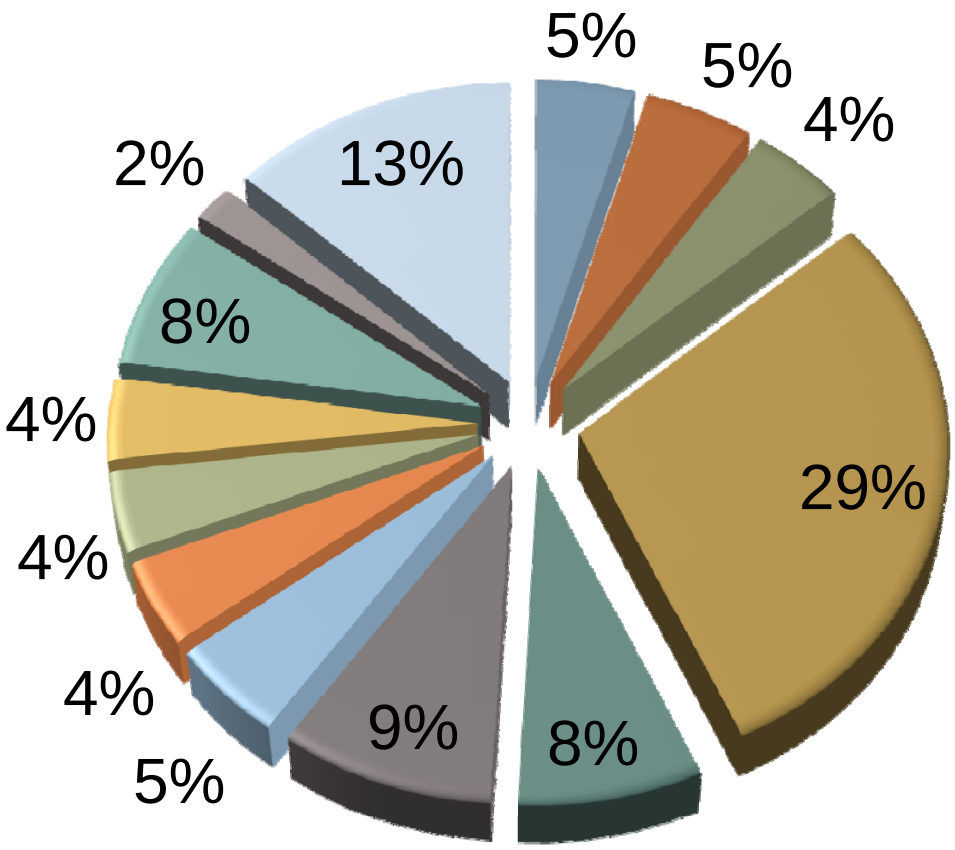
Total Time : 2905 ns

Push Time : 1572 ns

- Polling packet
- Refill receive DMA ring
- **Click forwarding path: push**
- Click forwarding path: pull
- Enqueue packet for transmit
- Clean transmit DMA ring

CPU Time Breakdown (Cont…)

Per element execution time



Total Time : 1455 ns
CheckIPHeader Time : 457 ns

Limitations

- Limitations of the tool
  - ***"Click"*** cannot be used to create the coarse-grained elements.
    - Coarse-grained elements are required when control or data flow doesn't match the flow of packets.
      - Ex. BGP.
  - ***"Click"*** cannot schedule the CPU per individual flow.
    - It is using stride algorithm for CPU scheduling.

- Limitations of the language
  - Compound element classes
    - Ex. The customized handlers implementation is not possible.
  - Compound elements are an imperfect abstraction mechanism.
    - They do not hide themselves from the user.
    - They are strictly less powerful than native element classes.

Conclusion

- Simple design
- Readable language configurations
- Better performance in smaller networks
- Easy to find faults because of modularity

References

[1] Eddie Kohler, Robert Morris, Benjie Chen, John Jannotti, and M. Frans Kaashoek. The Click modular router. *ACM Transactions on Computer Systems, 18(4),* November 2000.

[2] The Click Modular Router Project: *http://read.cs.ucla.edu/click/*

[3] Eddie Kohler, Click for Measurement**,** *UCLA Computer Science Department Technical Report TR060010,* February 2006

[4] Benjie Chen and Robert Morris, Flexible Control of Parallelism in a Multiprocessor PC Router, *USENIX 2001 Annual Technical Conference,* June 2001.