PIPELINE ARCHITECTURE

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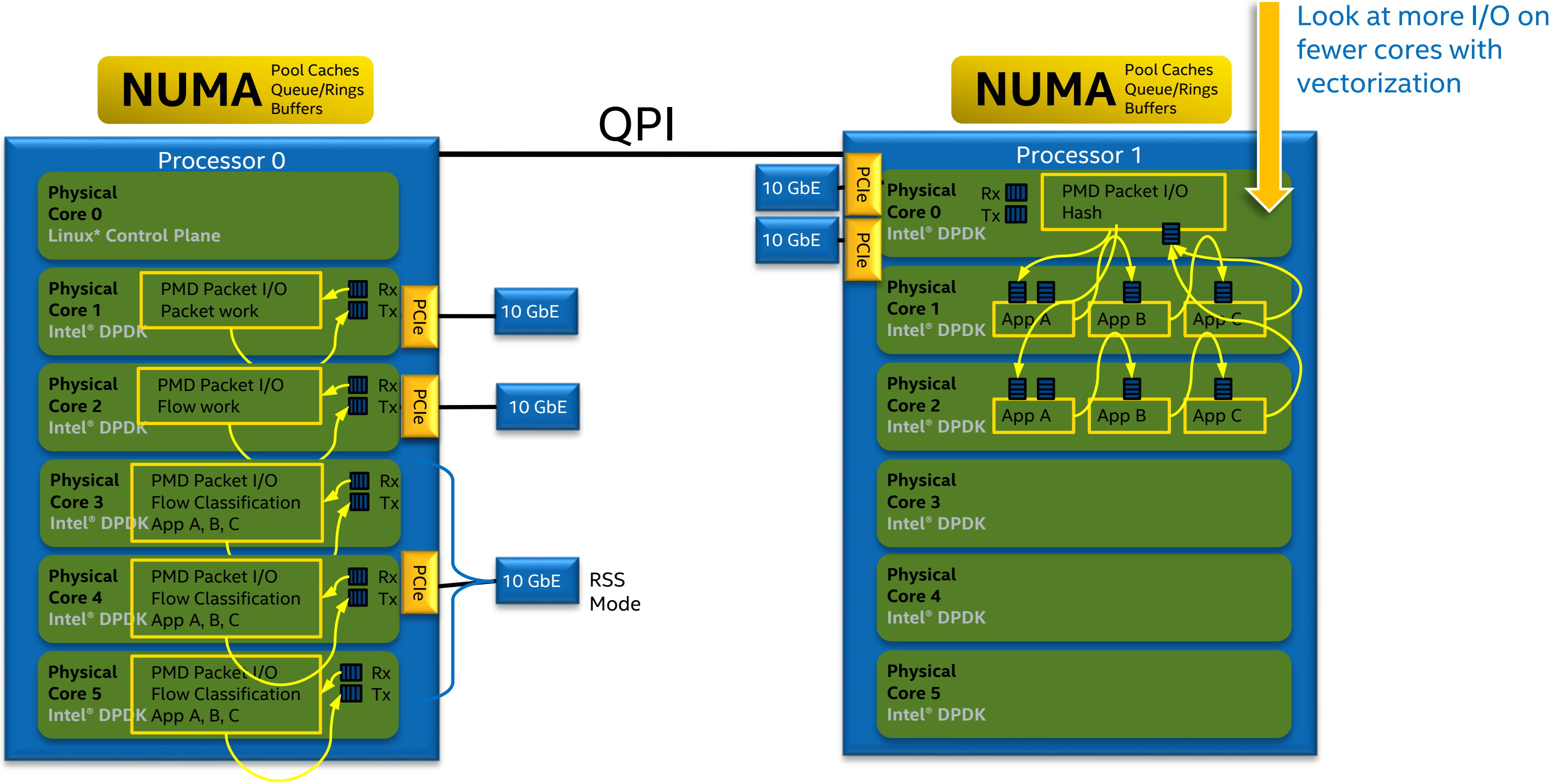
Run-to-completion vs pipeline software models



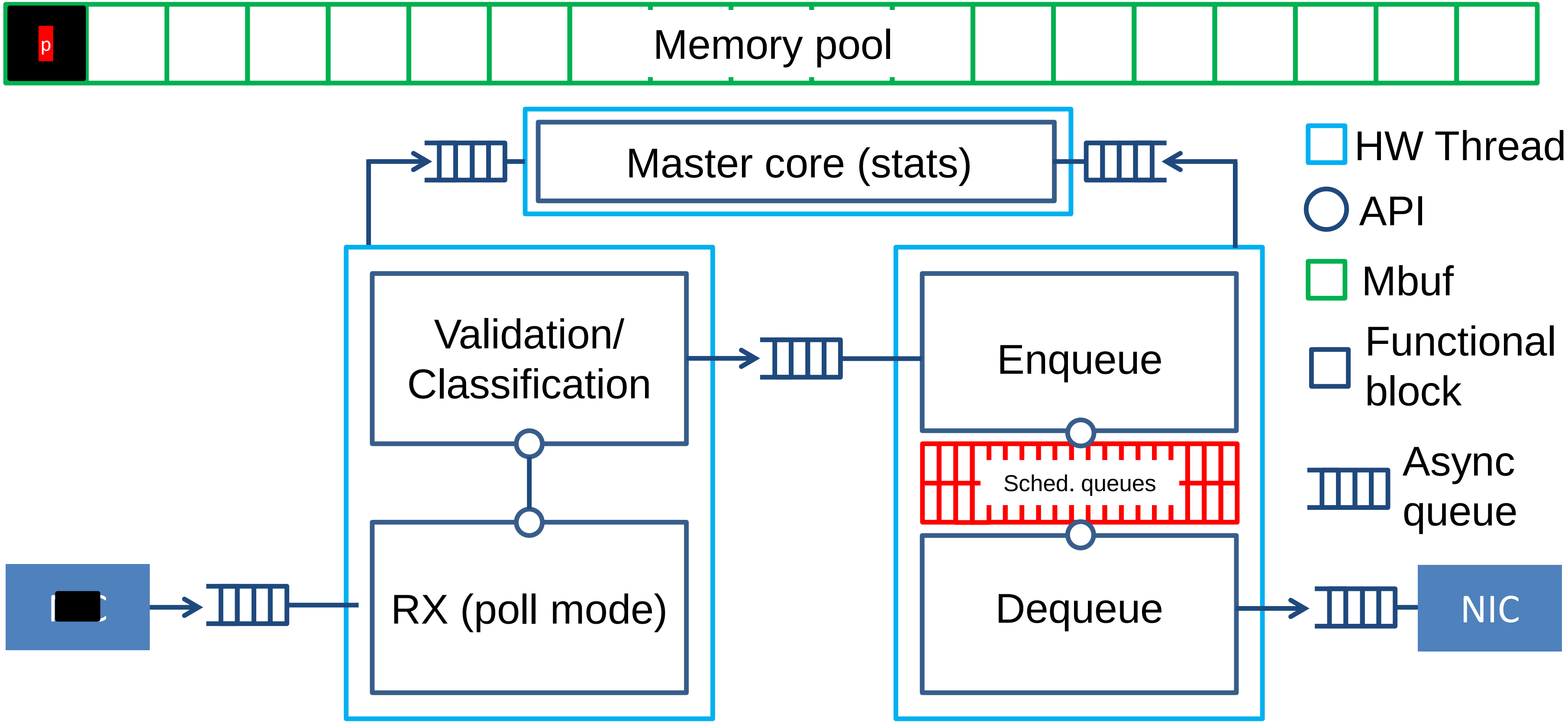
Run to Completion model

- I/O and Application workload can be handled on a single core
- I/O can be scaled over multiple cores

Pipeline model

- I/O application disperses packets to other cores
- Application work performed on other cores

Simple Pipeline application



Pipeline applications

DPDK Packet Framework

- development framework for building packet processing applications using standard pipeline blocks

DPPD: Data Plane Performance Demonstrators

- Linux user space applications based mainly intended for performance analysis purposes

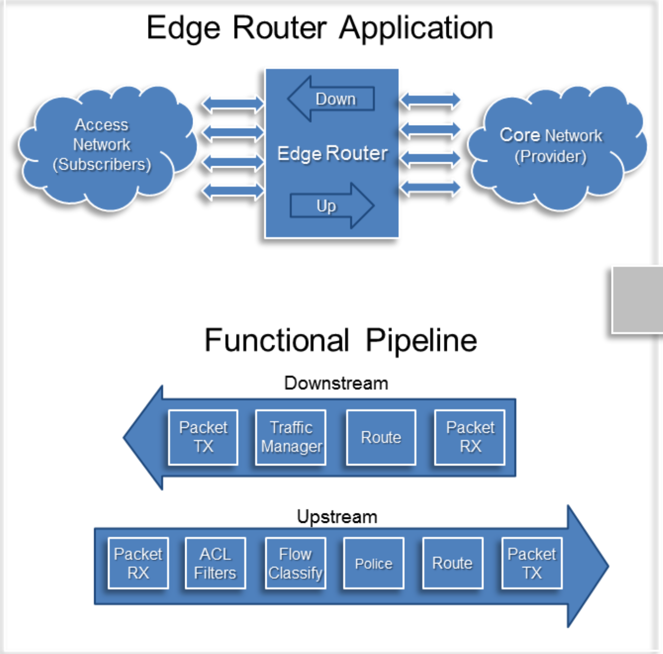
DPDK PACKET FRAMEWORK

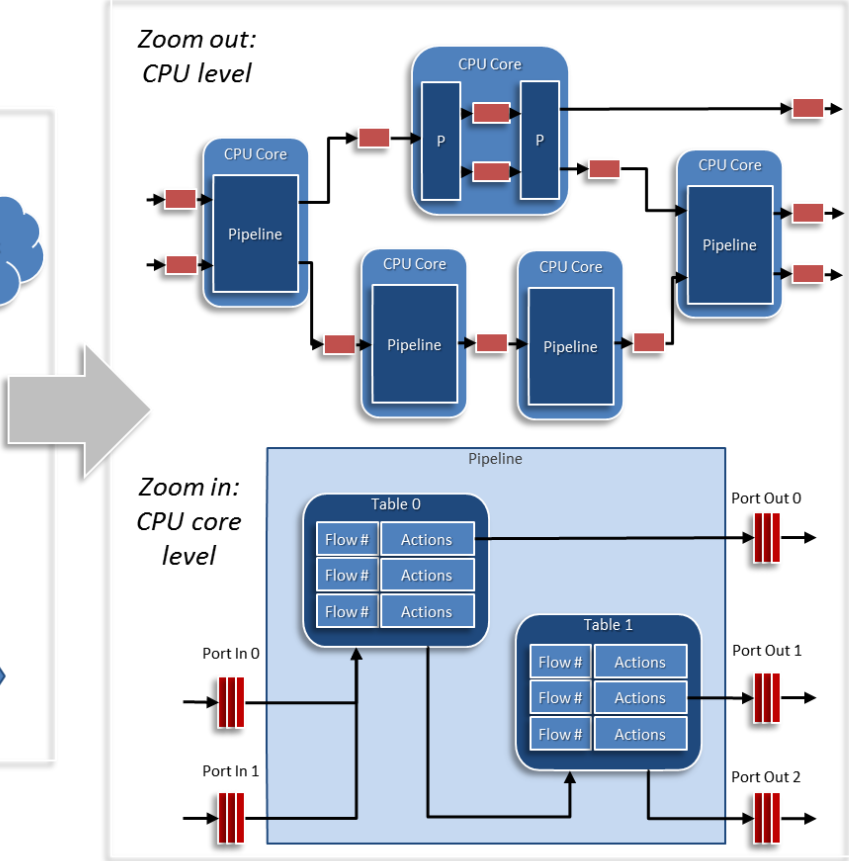
DPDK Programmer’s Guide, Packet Framework

DPDK Sample Applications User Guide, Internet Protocol (IP) Pipeline Sample Application

Rapid Development of Packet Processing Apps

DPDK Packet Framework quickly turns requirements into code





Packet Framework Components

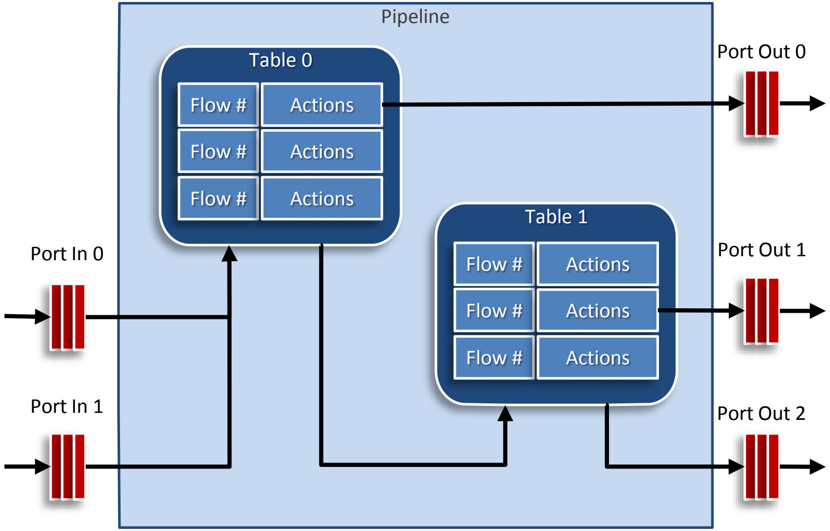
#	Component	
1	Port library	Port abstract interface API Basic ports: HWQ, SWQ Advanced ports: IP frag, IP ras, Traffic Mgr, KNI, QAT
2	Table library	Table abstract interface API Tables: Hash (Extendible bucket, LRU), ACL, LPM, Array
3	Pipeline library	Pipeline configuration and run-time API Configuration API implementation Run-time API implementation
4	IP Pipeline example	The Internet Protocol (IP) Pipeline application illustrates the use of the DPDK Packet Framework tool suite by implementing functional blocks such as packet RX, packet TX, flow classification, firewall, routing, IP fragmentation, IP reassembly, etc which are then assigned to different CPU cores and connected together to create complex multi-core applications.

DPDK Packet Framework, Pipeline Level

librte_port

Ports
HW queue
SW queue
IP Fragmentation
IP Reassembly
Traffic Mgr
KNI
Source/Sink

Zoom in: Pipeline level



librte_table

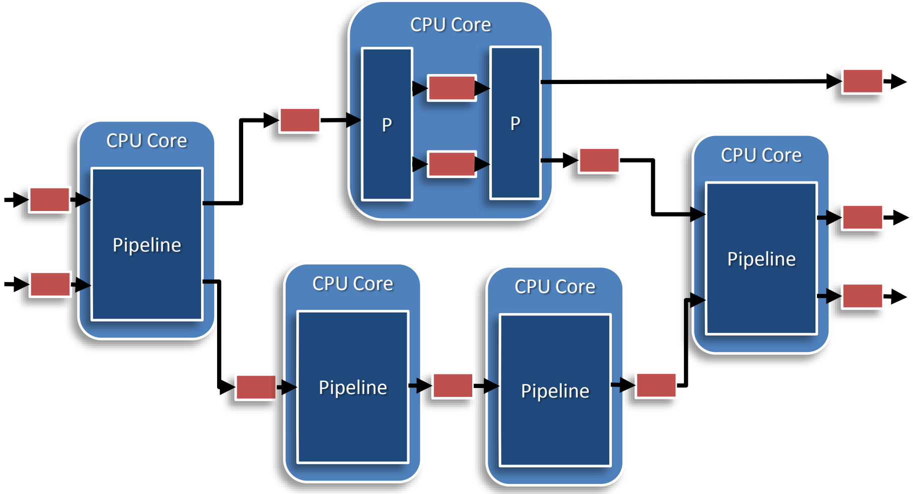
Tables
Exact Match / Hash
Access Control List (ACL)
Longest Prefix Match (LPM)
Array
Pattern Matching

Actions
Reserved actions: Send to port, Send to table, Drop
Packet edits: push/pop labels, modify headers (NAT, TTL update)
Flow-based: meter, stats, app ID
Accelerators: crypto, compress
Load Balancing

Standard methodology for ***pipeline*** development.
Ports and ***tables*** are connected together in tree-like topologies , with tables providing the ***actions*** to be executed on input packets.

DPDK Packet Framework, App Level

Zoom out: Multi-core application level



librte_pipeline

Pipelines
Packet I/O
Flow Classification
Firewall
Routing
Traffic Mgmt

The Framework breaks the app into multiple pipelines, assigns each pipeline to a specific core and chains the pipelines together

Multi-core scaling

A complex application is typically split across multiple cores, with cores communicating through SW queues

There is usually a performance limit on the number of table lookups and actions that can be fit on a single a single core (due to cache memory size, cache BW, memory BW, etc.)

The Framework breaks the app into multiple pipelines, assigns each pipeline to a specific core and chains pipelines together

One core can do more than one pipeline, but a pipeline cannot be split across multiple cores

INTEL® DATA PLANE PERFORMANCE DEMONSTRATORS

https://01.org/intel-data-plane-performance-demonstrators

Intel® DPPD: Data Plane Performance Demonstrators

An open source application

- BSD3C license

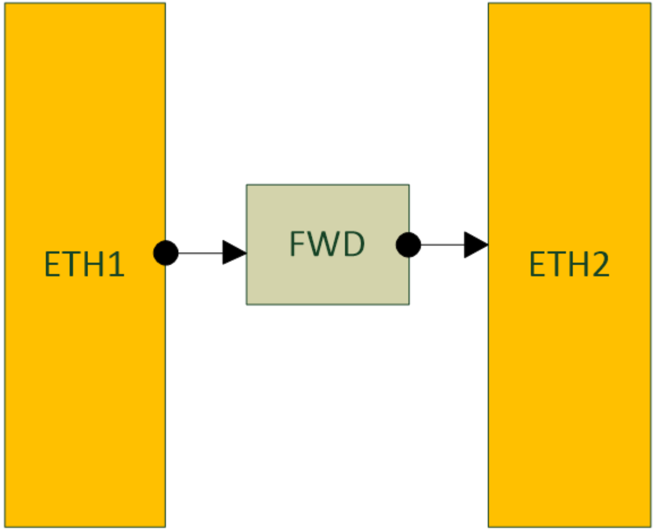
Config file defines

- Which cores are used
- Which interfaces are used
- Which tasks are executed and how configured

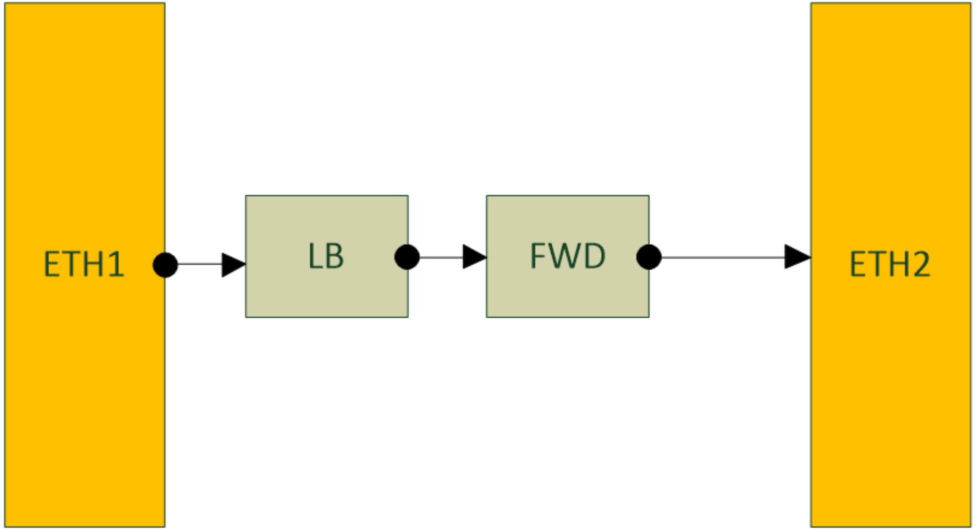
Allows to

- Find bottlenecks and measure performance
- Try and compare different core layouts without changing code
- Reuse config file on different systems (CPUs, hyper-threads, sockets, interfaces)

DPPD: Sample Configurations

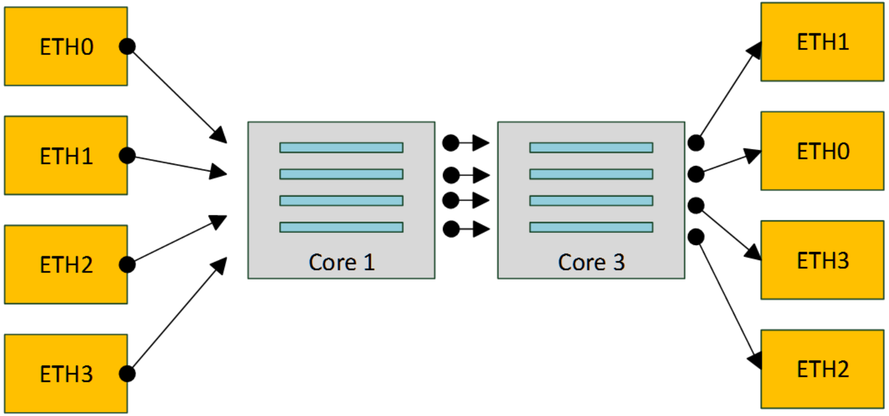


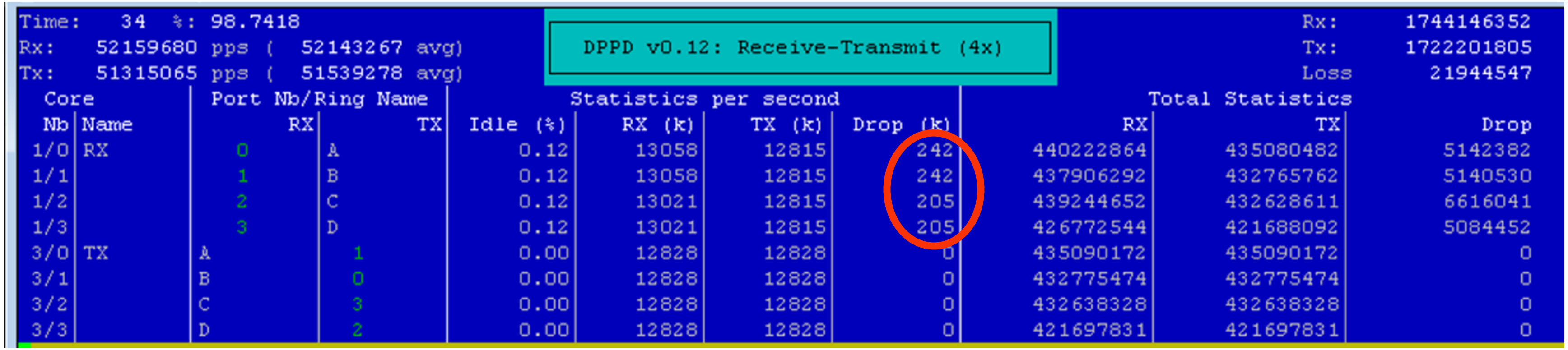
Very simple port forwarding



Simple load balancer and worker thread

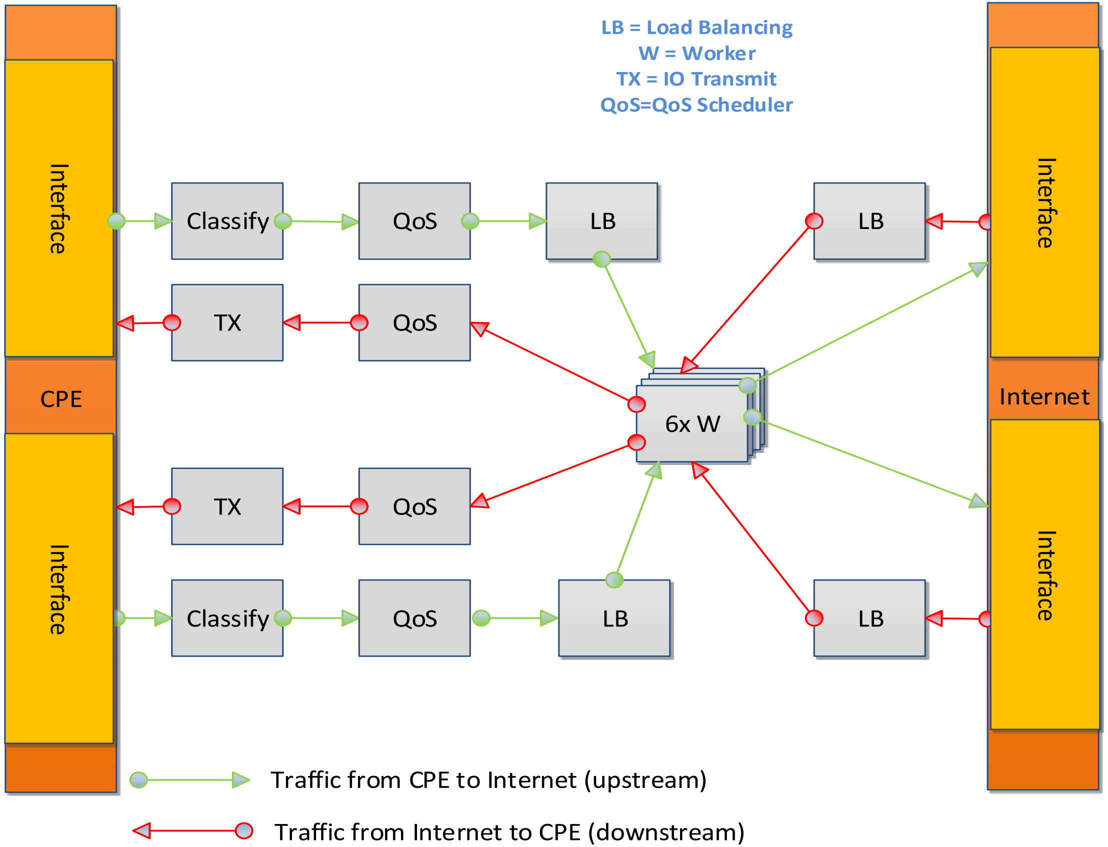
Finding bottlenecks



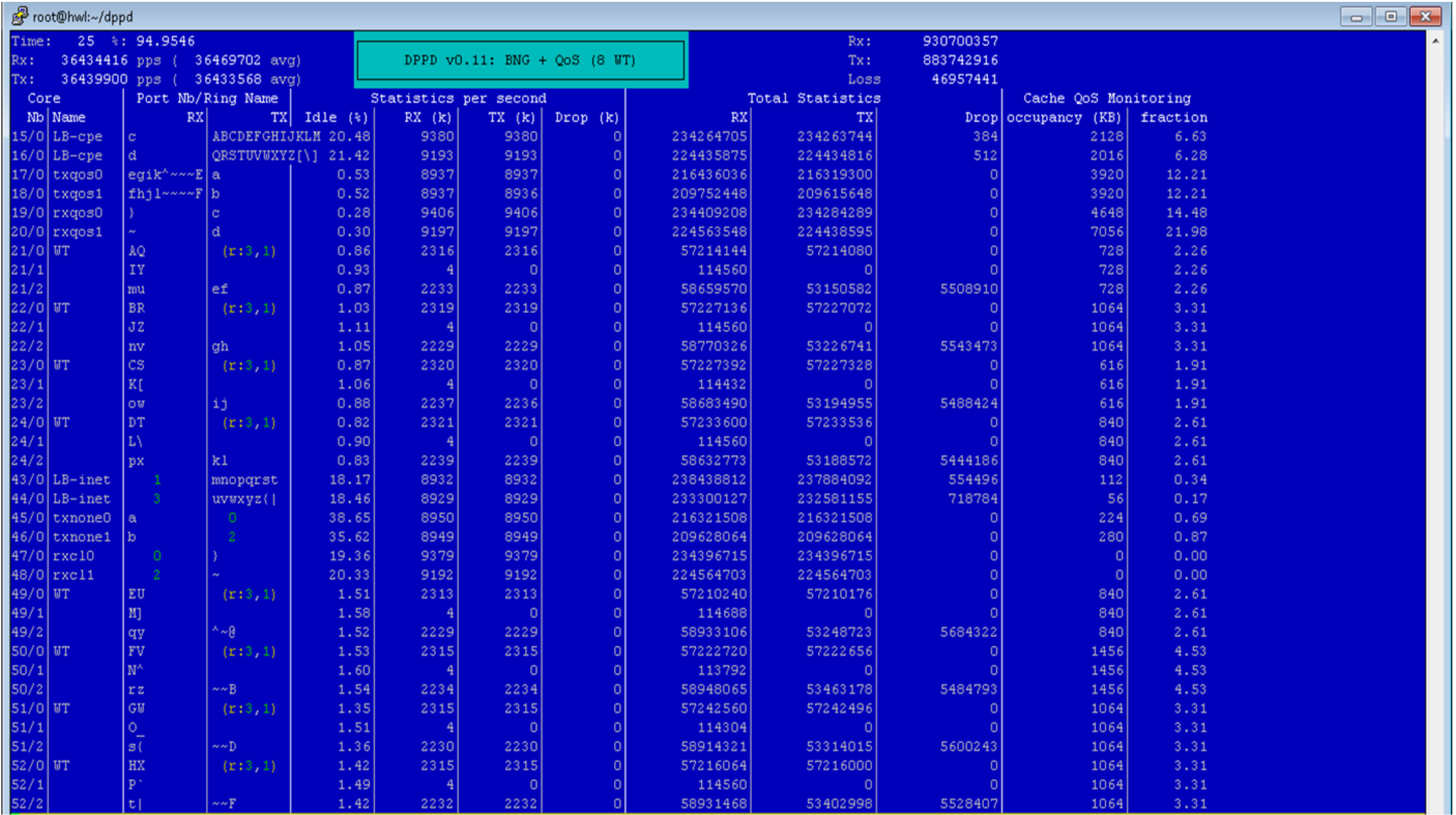


```
Time:    34  %: 98.7418                                                                 Rx:    1744146352
Rx:    52159680 pps (  52143267 avg)          DPPD v0.12: Receive-Transmit (4x)           Tx:    1722201805
Tx:    51315065 pps (  51539278 avg)                                                      Loss     21944547
  Core       Port Nb/Ring Name           Statistics per second                        Total Statistics
  Nb|Name             RX|       TX| Idle (%)|   RX (k)|   TX (k)| Drop (k)|          RX|          TX|          Drop
 1/0|RX               0 |A        |     0.12|    13058|    12815|      242|   440222864|   435080482|       5142382
 1/1|                 1 |B        |     0.12|    13058|    12815|      242|   437906292|   432765762|       5140530
 1/2|                 2 |C        |     0.12|    13021|    12815|      205|   439244652|   432628611|       6616041
 1/3|                 3 |D        |     0.12|    13021|    12815|      205|   426772544|   421688092|       5084452
 3/0|TX        A        |       1 |     0.00|    12828|    12828|        0|   435090172|   435090172|             0
 3/1|          B        |       0 |     0.00|    12828|    12828|        0|   432775474|   432775474|             0
 3/2|          C        |       3 |     0.00|    12828|    12828|        0|   432638328|   432638328|             0
 3/3|          D        |       2 |     0.00|    12828|    12828|        0|   421697831|   421697831|             0
```

QoS and BNG(simplified view)



DPPD Display



root@hwl:~/dppd

```
Time:    25  %: 94.9546                          DPPD v0.11: BNG + QoS (8 WT)                Rx:        930700357
Rx:    36434416 pps (  36469702 avg)                                                            Tx:        883742916
Tx:    36439900 pps (  36433568 avg)                                                            Loss        46957441
  Core      |  Port Nb/Ring Name  |         Statistics per second           |            Total Statistics                 |  Cache QoS Monitoring
  Nb|Name    |       RX|       TX| Idle (%)|   RX (k)|   TX (k)| Drop (k)|            RX|            TX|          Drop|occupancy (KB)| fraction
15/0|LB-cpe  |c        |ABCDEFGHIJKLM 20.48|     9380|     9380|        0|     234264705|     234263744|           384|          2128|     6.63
16/0|LB-cpe  |d        |QRSTUVWXYZ[\] 21.42|     9193|     9193|        0|     224435875|     224434816|           512|          2016|     6.28
17/0|txqos0  |egik^~~~E|a        |     0.53|     8937|     8937|        0|     216436036|     216319300|             0|          3920|    12.21
18/0|txqos1  |fhjl~~~~F|b        |     0.52|     8937|     8936|        0|     209752448|     209615648|             0|          3920|    12.21
19/0|rxqos0  |}        |c        |     0.28|     9406|     9406|        0|     234409208|     234284289|             0|          4648|    14.48
20/0|rxqos1  |~        |d        |     0.30|     9197|     9197|        0|     224563548|     224438595|             0|          7056|    21.98
21/0|WT      |AQ       |  (r:3,1)|     0.86|     2316|     2316|        0|      57214144|      57214080|             0|           728|     2.26
21/1|        |IY       |         |     0.93|        4|        0|        0|        114560|             0|             0|           728|     2.26
21/2|        |mu       |ef       |     0.87|     2233|     2233|        0|      58659570|      53150582|       5508910|           728|     2.26
22/0|WT      |BR       |  (r:3,1)|     1.03|     2319|     2319|        0|      57227136|      57227072|             0|          1064|     3.31
22/1|        |JZ       |         |     1.11|        4|        0|        0|        114560|             0|             0|          1064|     3.31
22/2|        |nv       |gh       |     1.05|     2229|     2229|        0|      58770326|      53226741|       5543473|          1064|     3.31
23/0|WT      |CS       |  (r:3,1)|     0.87|     2320|     2320|        0|      57227392|      57227328|             0|           616|     1.91
23/1|        |K[       |         |     1.06|        4|        0|        0|        114432|             0|             0|           616|     1.91
23/2|        |ow       |ij       |     0.88|     2237|     2236|        0|      58683490|      53194955|       5488424|           616|     1.91
24/0|WT      |DT       |  (r:3,1)|     0.82|     2321|     2321|        0|      57233600|      57233536|             0|           840|     2.61
24/1|        |L\       |         |     0.90|        4|        0|        0|        114560|             0|             0|           840|     2.61
24/2|        |px       |kl       |     0.83|     2239|     2239|        0|      58632773|      53188572|       5444186|           840|     2.61
43/0|LB-inet |   1     |mnopqrst |    18.17|     8932|     8932|        0|     238438812|     237884092|        554496|           112|     0.34
44/0|LB-inet |   3     |uvwxyz{| |    18.46|     8929|     8929|        0|     233300127|     232581155|        718784|            56|     0.17
45/0|txnone0 |a        |  0      |    38.65|     8950|     8950|        0|     216321508|     216321508|             0|           224|     0.69
46/0|txnone1 |b        |  2      |    35.62|     8949|     8949|        0|     209628064|     209628064|             0|           280|     0.87
47/0|rxcl0   |   0     |}        |    19.36|     9379|     9379|        0|     234396715|     234396715|             0|             0|     0.00
48/0|rxcl1   |   2     |~        |    20.33|     9192|     9192|        0|     224564703|     224564703|             0|             0|     0.00
49/0|WT      |EU       |  (r:3,1)|     1.51|     2313|     2313|        0|      57210240|      57210176|             0|           840|     2.61
49/1|        |M]       |         |     1.58|        4|        0|        0|        114688|             0|             0|           840|     2.61
49/2|        |qy       |^~@      |     1.52|     2229|     2229|        0|      58933106|      53248723|       5684322|           840|     2.61
50/0|WT      |FV       |  (r:3,1)|     1.53|     2315|     2315|        0|      57222720|      57222656|             0|          1456|     4.53
50/1|        |N^       |         |     1.60|        4|        0|        0|        113792|             0|             0|          1456|     4.53
50/2|        |rz       |~~B      |     1.54|     2234|     2234|        0|      58948065|      53463178|       5484793|          1456|     4.53
51/0|WT      |GW       |  (r:3,1)|     1.35|     2315|     2315|        0|      57242560|      57242496|             0|          1064|     3.31
51/1|        |O_       |         |     1.51|        4|        0|        0|        114304|             0|             0|          1064|     3.31
51/2|        |s{       |~~D      |     1.36|     2230|     2230|        0|      58914321|      53314015|       5600243|          1064|     3.31
52/0|WT      |HX       |  (r:3,1)|     1.42|     2315|     2315|        0|      57216064|      57216000|             0|          1064|     3.31
52/1|        |P`       |         |     1.49|        4|        0|        0|        114560|             0|             0|          1064|     3.31
52/2|        |t|       |~~F      |     1.42|     2232|     2232|        0|      58931468|      53402998|       5528407|          1064|     3.31
```

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