Analysis of high-performance software NAT design approaches

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What is a Network Address Translator (NAT)?

- Component of data networking equipment

- Standard and integral equipment for Internet Service Provider (ISP) data networks

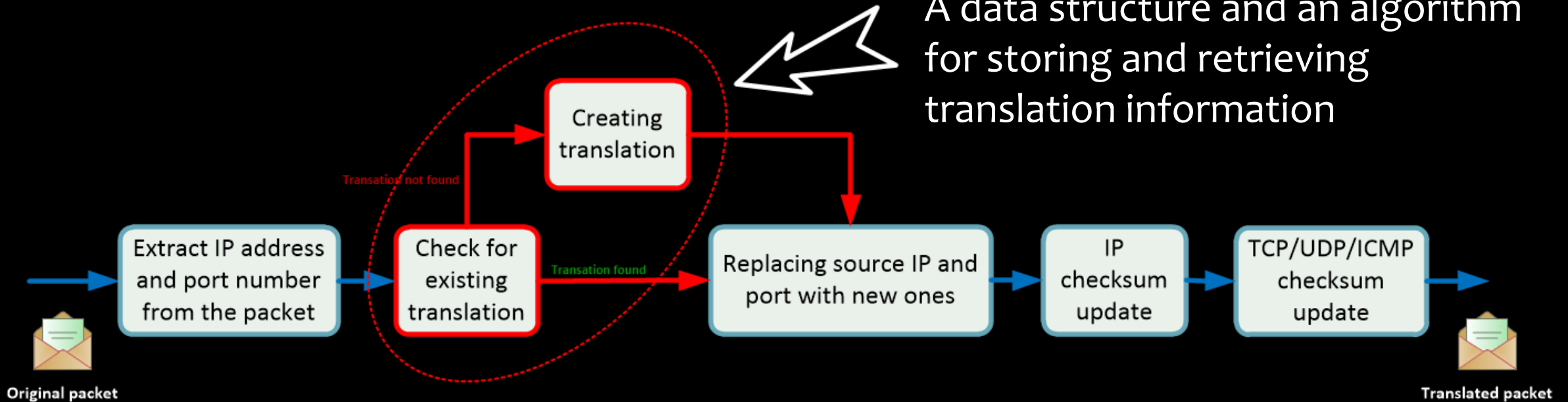- If high performance is needed – a specially designed device is used

Hardware NAT VS. Software NAT

	Hardware NAT	Software NAT
Typical form-factor		
Characteristics	Throughput: 10G bits per sec **Packet processing rate**: 5.5M packets per sec Connection setup rate: 3M sessions per sec Concurrent session support: 65.5M sessions	**Limited by an underlying OS. Typically:** Throughput: 1G bits per sec **Packet processing rate**: 300K packets per sec worse than hardware NAT
Architecture	• Specialized processors and integral circuits • CAM modules(associative memory) based • Proprietary software	A commodity server with original software installed
Price	min $ 6000	Around $ 3000 cheaper than hardware NAT

Improving of Software NAT Performance

Packet translation workflow

Performance bottleneck:

A data structure and an algorithm for storing and retrieving translation information

Creating translation

Transation not found

Extract IP address and port number from the packet

Check for existing translation

Transation found

Replacing source IP and port with new ones

IP checksum update

TCP/UDP/ICMP checksum update
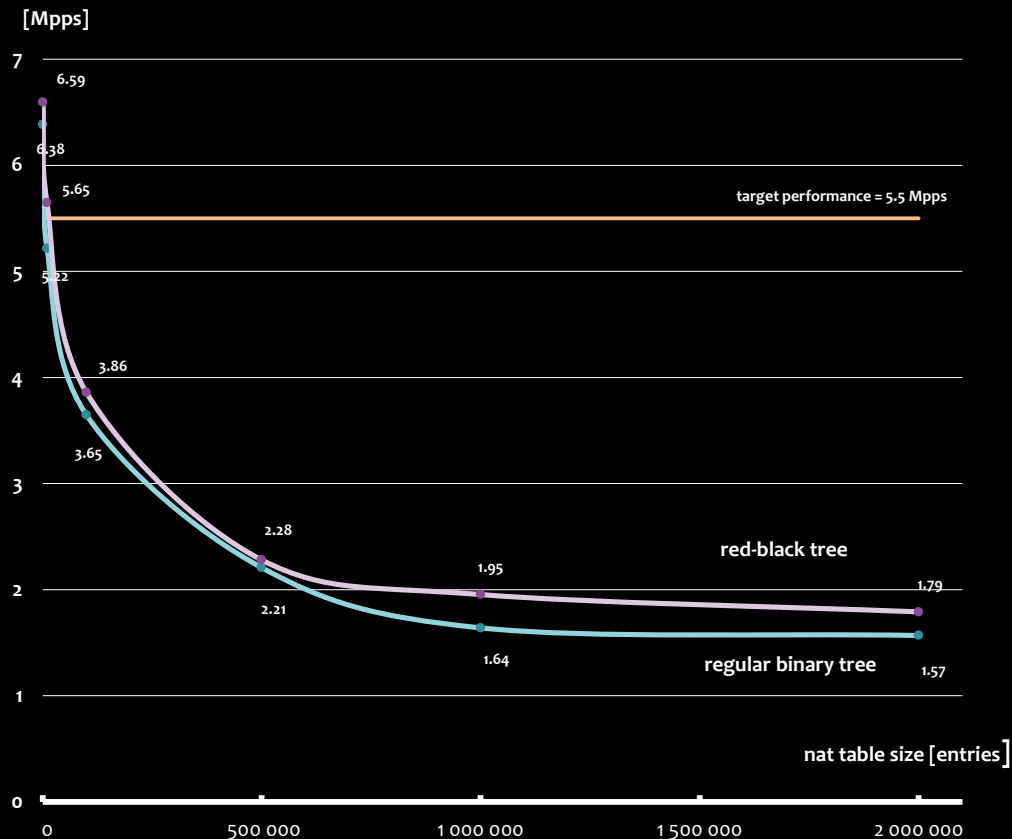
Original packet

Translated packet

Software Defined NAT Target Characteristics

- Throughput: 10G bits per sec

- **Packet processing rate**: 10M packets per sec

- Connection setup rate: 3M sessions per sec

- Concurrent session support: 65.5M sessions

Approaching the target characteristics by improving the translation algorithm
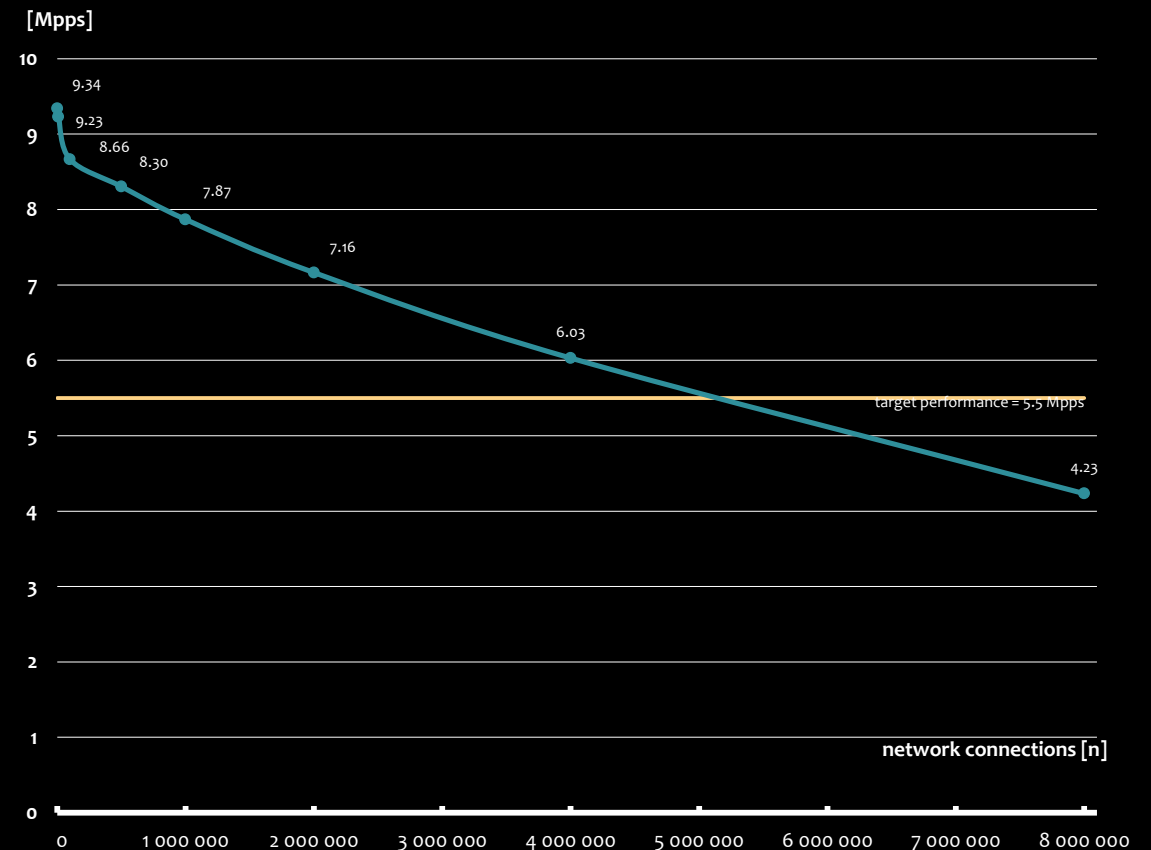

Binary tree-based NAT table
CPU: i5-4210U@2.4GHz, 1 core

[Mpps]

7

6.59
6.38

5.65

target performance = 5.5 Mpps

5.22

3.86

3.65

2.28

red-black tree

1.95
2.21
1.79
1.64
regular binary tree
1.57

nat table size [entries]

0   500 000   1 000 000   1 500 000   2 000 000

Hash-based NAT table
CPU: i5-4210U@2.4 GHz, 1 core
modulo value: 2^23

[Mpps]

10

9.34
9.23
8.66
8.30
7.87
7.16
6.03
target performance = 5.5 Mpps
4.23

network connections [n]

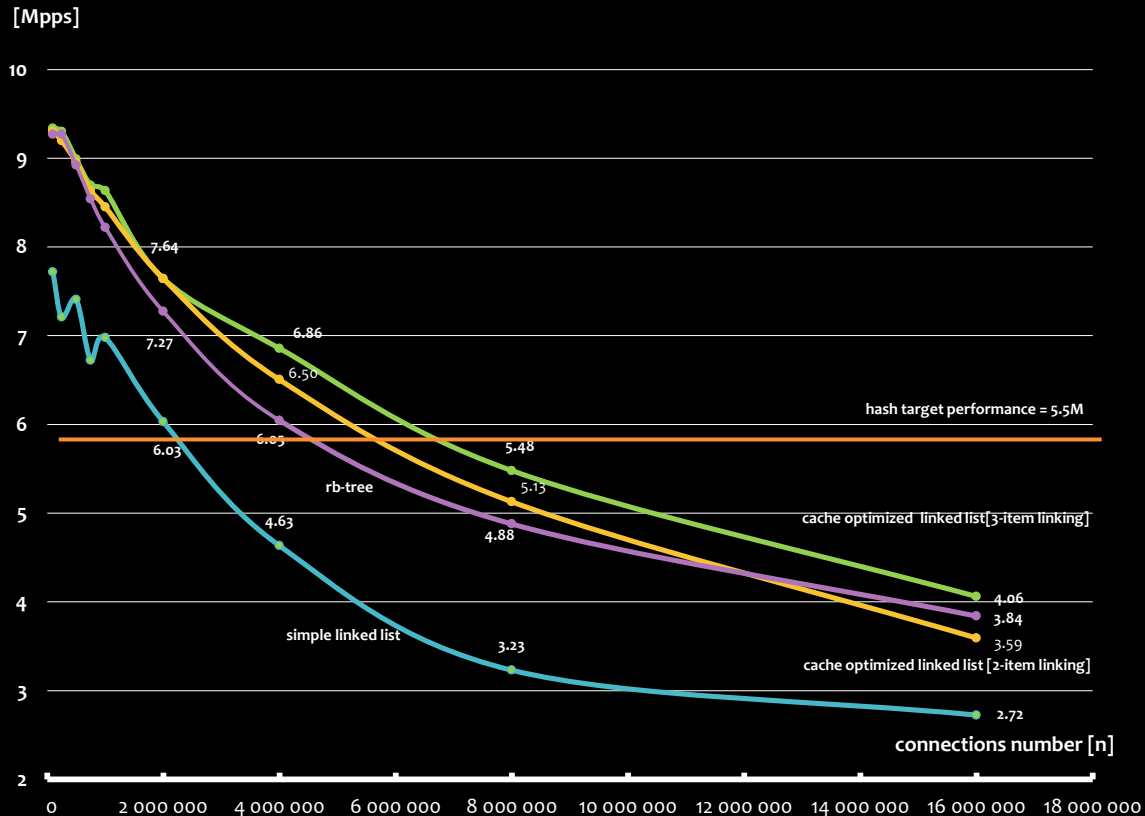0   1 000 000   2 000 000   3 000 000   4 000 000   5 000 000   6 000 000   7 000 000   8 000 000

Approaching the target characteristics by improving the translation algorithm (cont'd)

Hash table performance comparison
CPU: i5-4210U, 1 core
modulo value: 2^21

[Mpps]

hash target performance = 5.5M

7.64
7.27
6.86
6.50
6.03
6.85
5.48
5.13
4.63
4.88
4.06
3.84
3.59
3.23
2.72

rb-tree
cache optimized linked list[3-item linking]
simple linked list
cache optimized linked list [2-item linking]

connections number [n]

0   2 000 000   4 000 000   6 000 000   8 000 000   10 000 000   12 000 000   14 000 000   16 000 000   18 000 000

Parallel processing
CPU: i5-4210U, 1-4 cores

[Mpps]

14.29   14.20   13.87   14.04   14.37   14.20
13.87

12.44   12.44   12.44   12.44   12.31   11.59
12.00
10.62
9.84   8.60   9.02   8.86   8.63   8.45

4 cores
3 cores
2 cores

5.83   5.77   5.99   5.93   5.58
5.28   5.36   4.83   4.18

target performance = 5.5

1 core

network connections [n]

0   4 000 000   8 000 000   12 000 000   16 000 000   20 000 000   24 000 000
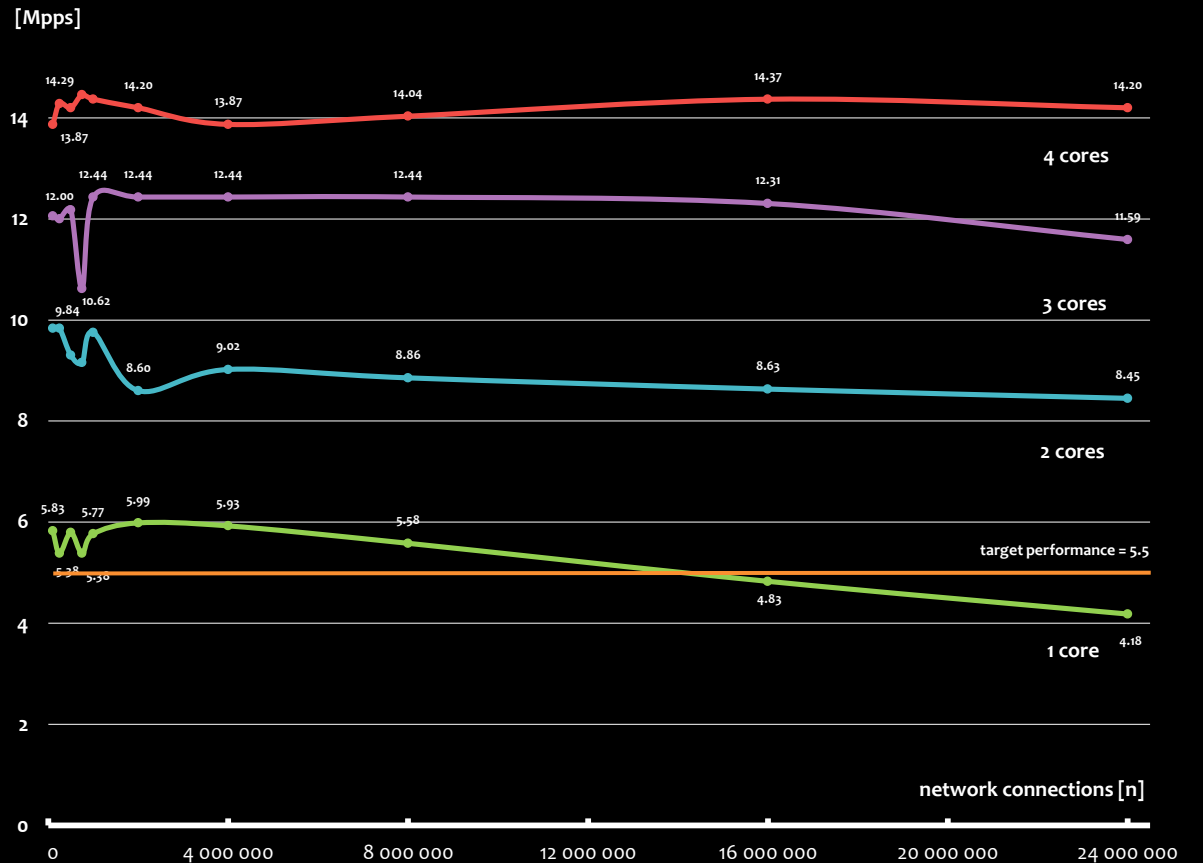
The prototype improves translation tables by using the optimized hash-table exceeded the target characteristics and showed 14.2 Mpps packet processing rate

Benefits of The Software NAT

- Costs 50% less than a traditional NAT, but has the same performance characteristics

- Easily upgradable

- Easily maintainable
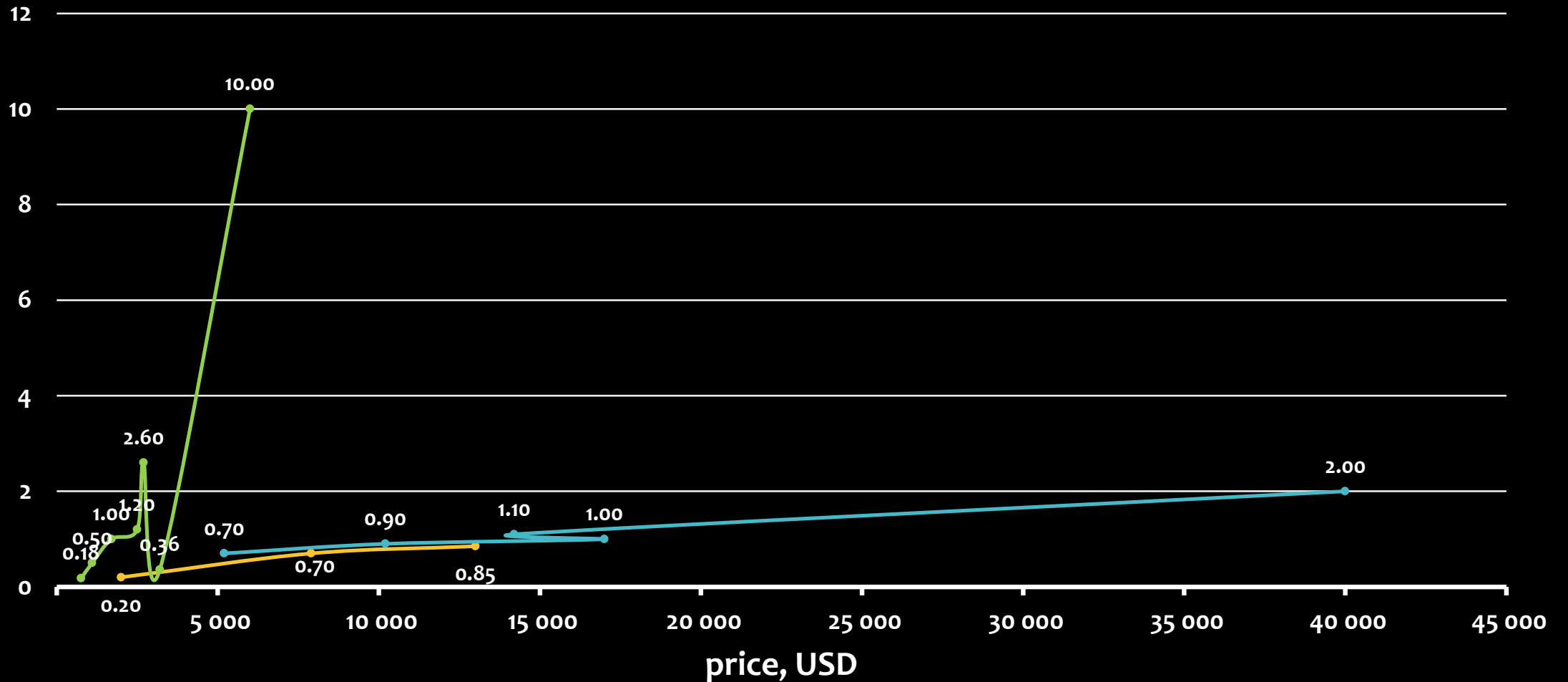
- More performance on upcoming processors

THANK YOU!

Traditional NAT prices

The Software NAT Cost Estimation

Component name	Model	Price, $
Processor	Intel Core i5-4690	220
RAM Modules	SiliconPower SP016GXLYU16ANDA x2	320
Motherboard	SuperMicro X10SLL-S (Intel C222)	200
Hard Disk	Intel DC S3610	275
Network Interface Card	Lenovo 10Gb X540-T2	600
System Unit	SuperMicro CSE-732D2-500B	200

TOTAL: $1815