ons
EUROPE
OPEN NETWORKING //
Integrate, Automate, Accelerate

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High Performance Cloud-native Networking

K8s Unleashing FD.io

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DISCLAIMERs

- **'Mileage May Vary'**
  - Tests document performance of components on a particular test, in specific systems. Differences in hardware, software, or configuration will affect actual performance. Consult other sources of information to evaluate performance as you consider your opinion and investment of any resources. For more complete information about open source performance and benchmark results referred in this material, visit https://wiki.fd.io/view/CSIT and/or https://docs.fd.io/csit/rls1807/report/.
- **Trademarks and Branding**
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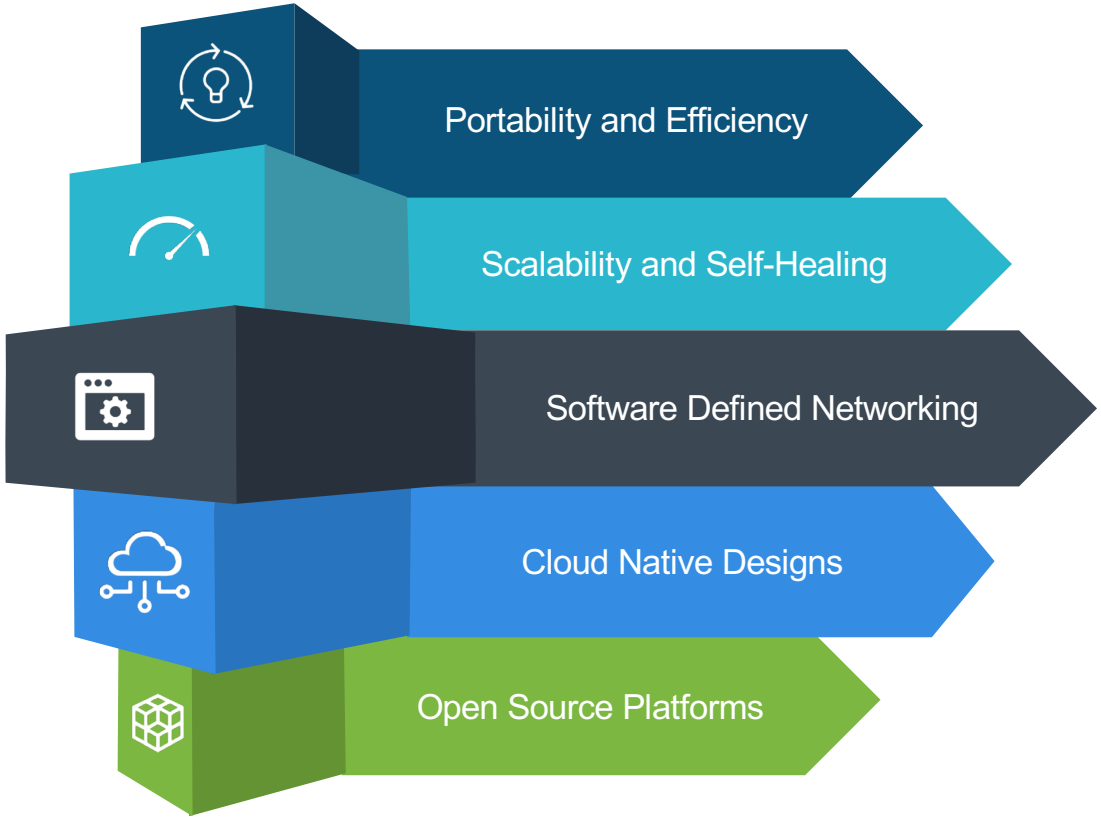
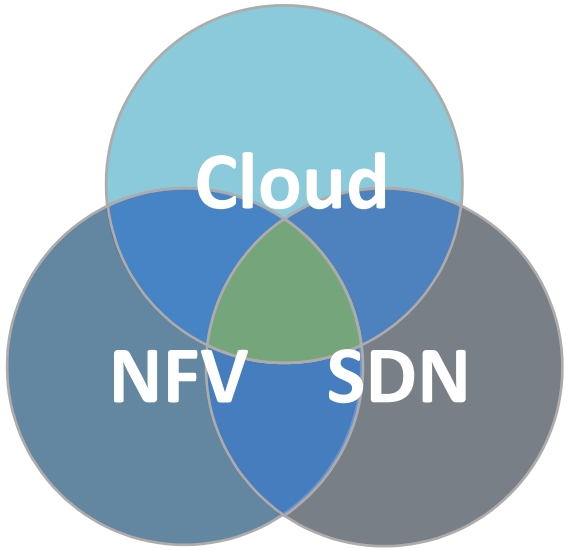
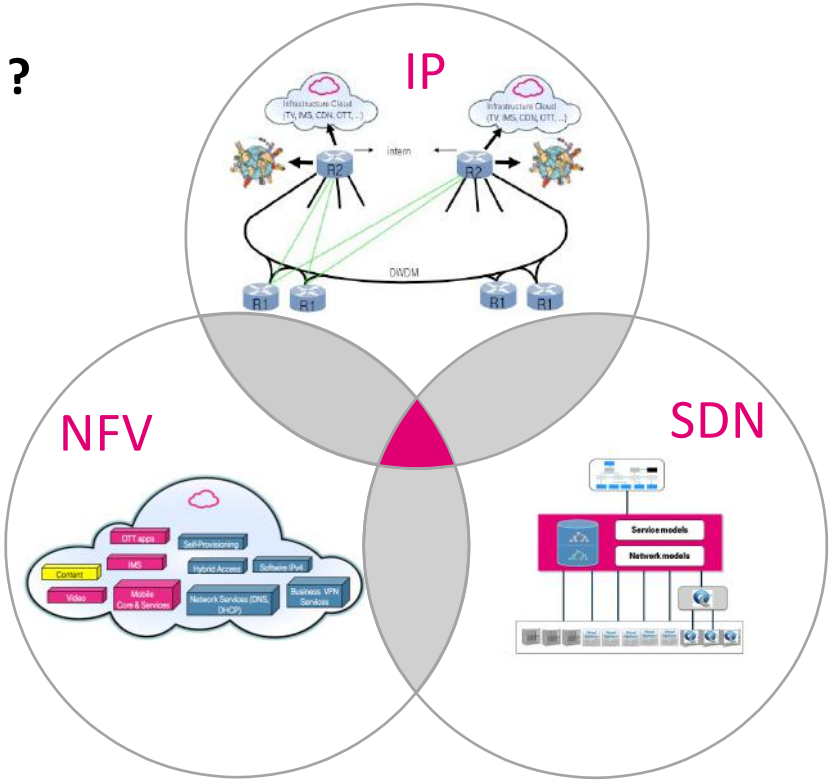
Internet Mega Trends – ..





THE SOFTWARE DEFINED OPERATOR

DO YOU REMEMBER .. ?



5 Pillars of Next Generation Software Data Planes

Blazingly Fast

- Process the *massive explosion* of East-West traffic
- Process *increasing* North-South traffic

Software First

- Cloud means *running everywhere*
- Cloud means hardware and physical *infra agnostic*

Truly Extensible

- Foster *pace of innovation* in cloud-native networking
- *No compromise* on performance (zero-tolerance)

Predictable performance

- Dataplane performance must be deterministic
- Predictable for a number of VMs, Containers, virtual topology and (E-W, N-S) traffic matrix

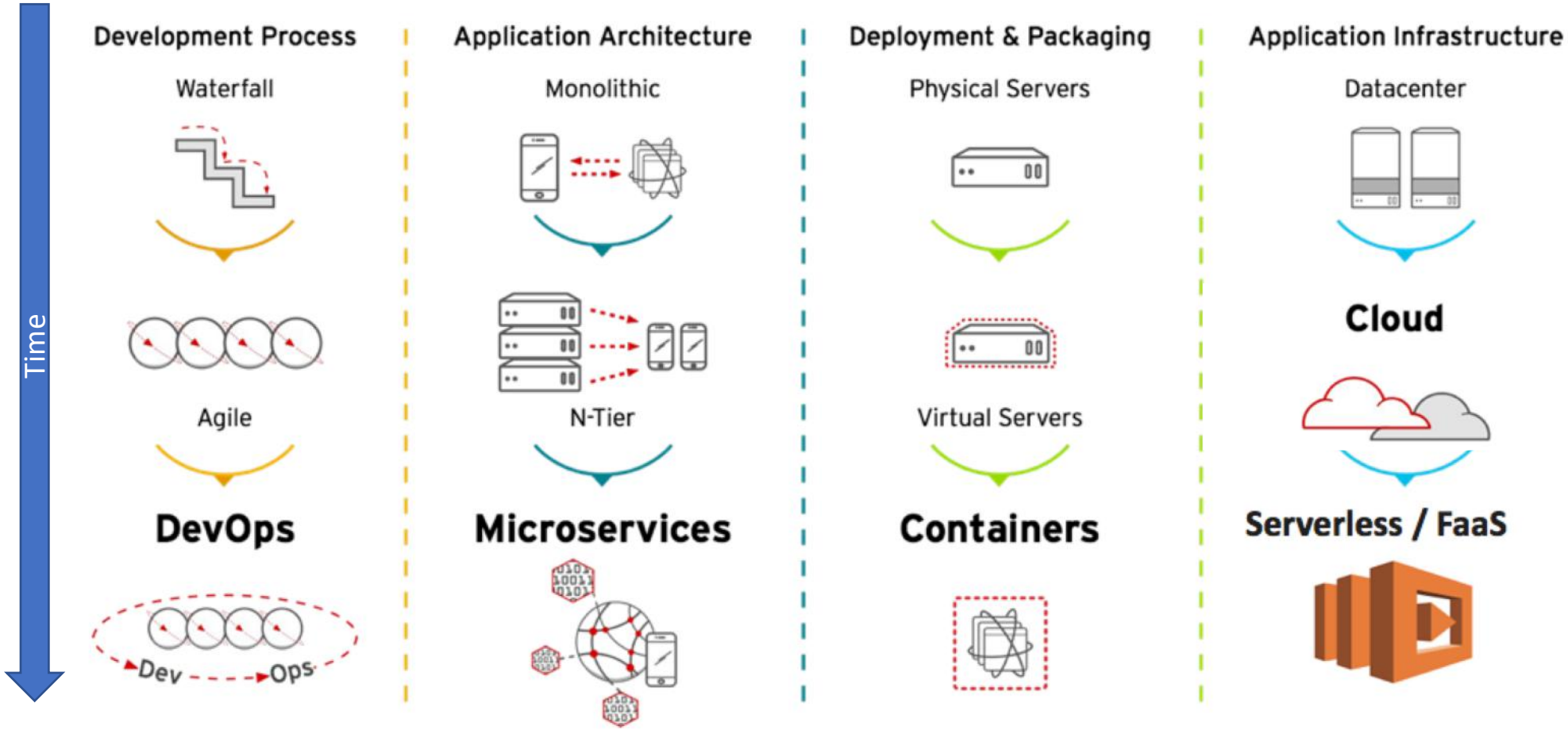
Measureable

- Counters everywhere to *count everything* for detailed cross-layer operation and efficiency monitoring
- Enables feedback loop to drive optimizations

FD.io VPP meets these challenges

How can one use it in large scale Cloud-native networks ?

The Way Applications Are Developed and Deployed.. Has Changed..

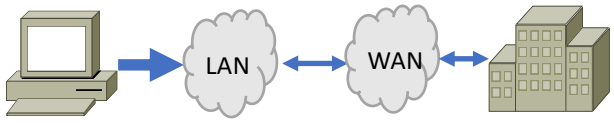


The Way Networks are Deployed and Used… has Changed…

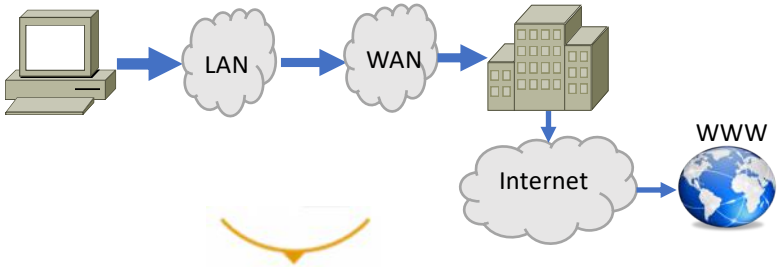
Time

Corporate LAN/WAN

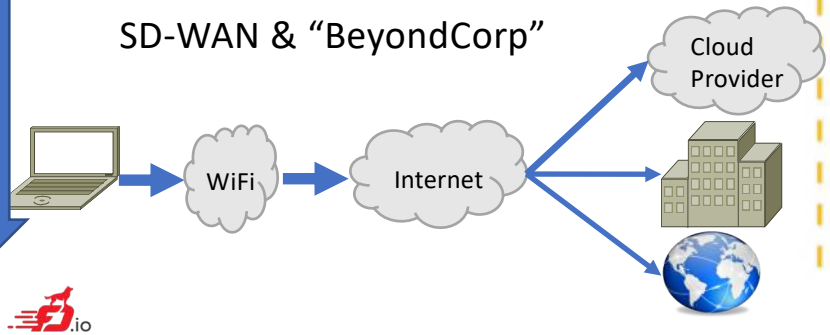
"80:20 rule"



Intranets & Internet

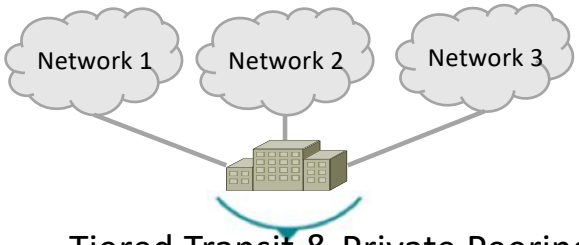


SD-WAN & "BeyondCorp"

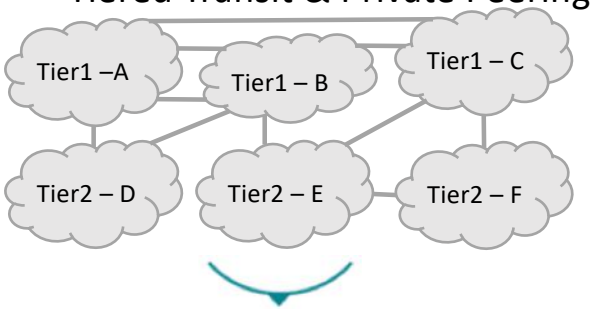


Internet

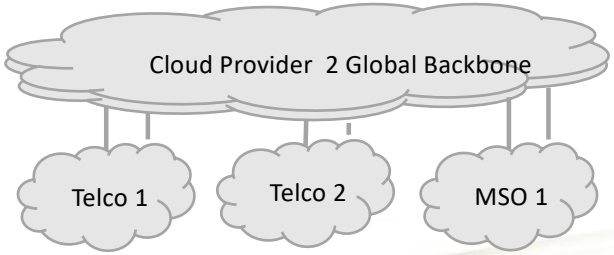
Internet exchanges & public peering



Tiered Transit & Private Peering

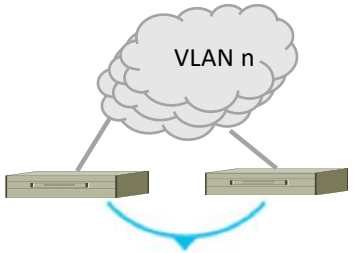


Telco/Cable Access &, OTT/CDN Content

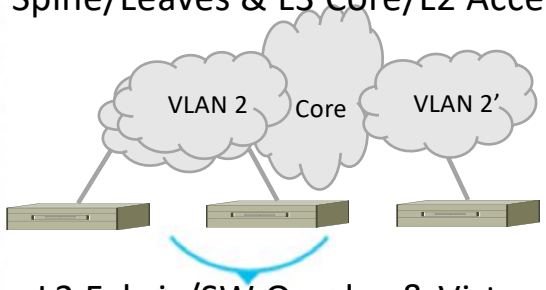


Data-Center

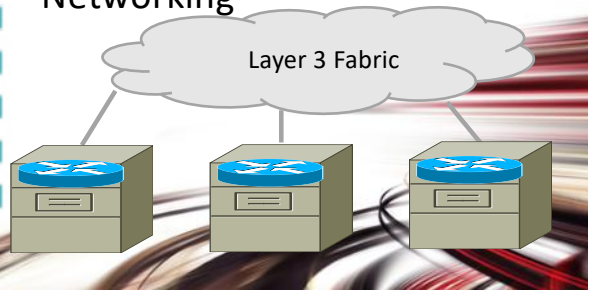
Core/Distr/Access, VLAN based



Spine/Leaves & L3 Core/L2 Access



L3 Fabric/SW Overlay & Virt Networking



Aside: A Trip Down Memory Lane (Transporting Data vs. Processing Data)

Cable TV Provider
Content Producer

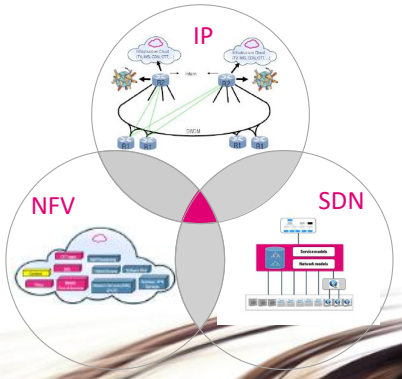
- **Year 2012**
  - Internet service provider comment at IETF: **processing bits is cheaper** than transporting bits, computing and networking - networking is becoming 1st order citizen on compute platforms.

TERASTREAM

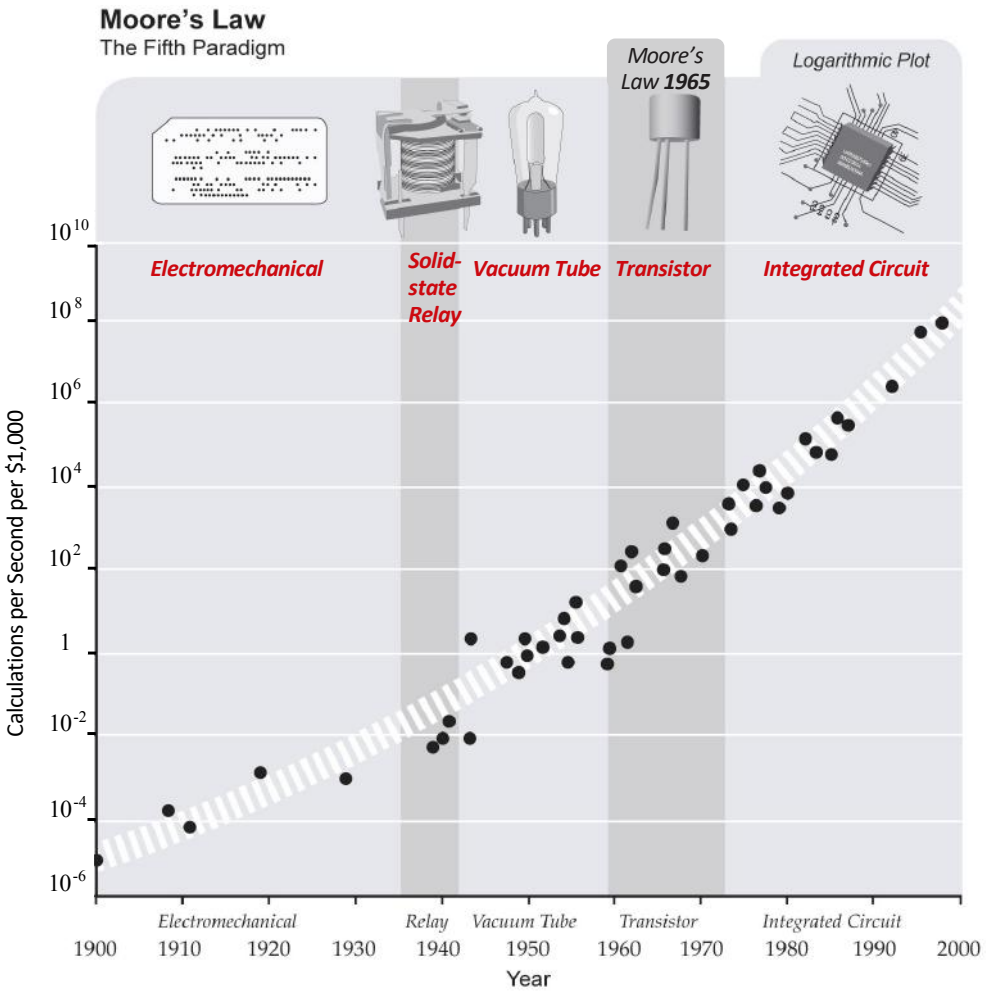
- **Year 2013**
  - RIPE67 Terastream been fixing the cost of transporting bits - 96 of 100GE coherent lambdas per fibre span - **transporting is getting cheaper**, so challenging the compute part again
  - more bandwidth delivered to Data Centres
  - **Most/all network services in Data Dentres**

    https://ripe67.ripe.net/archives/video/3/

    https://ripe67.ripe.net/presentations/131-ripe2-2.pdf



Remember **1965** ”Moore’s Law” – ..



Source: Ray Kurzweil, "The Singularity Is Near: When Humans Transcend Biology", Page 67, The Duckworth Publishers 2009. Data points between 1600 and 1900, and after 2000 represent Maciek's perspective and approximations.

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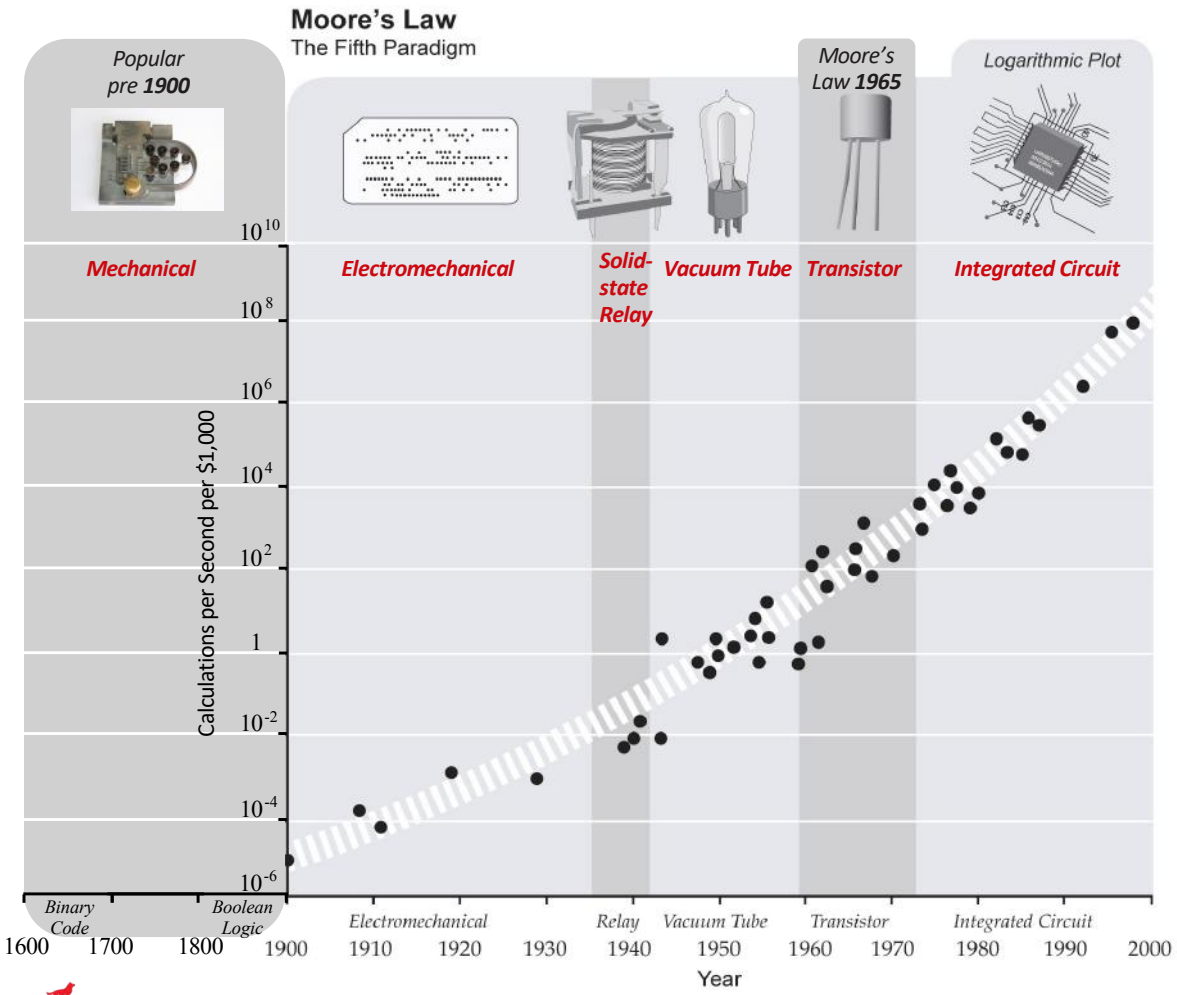

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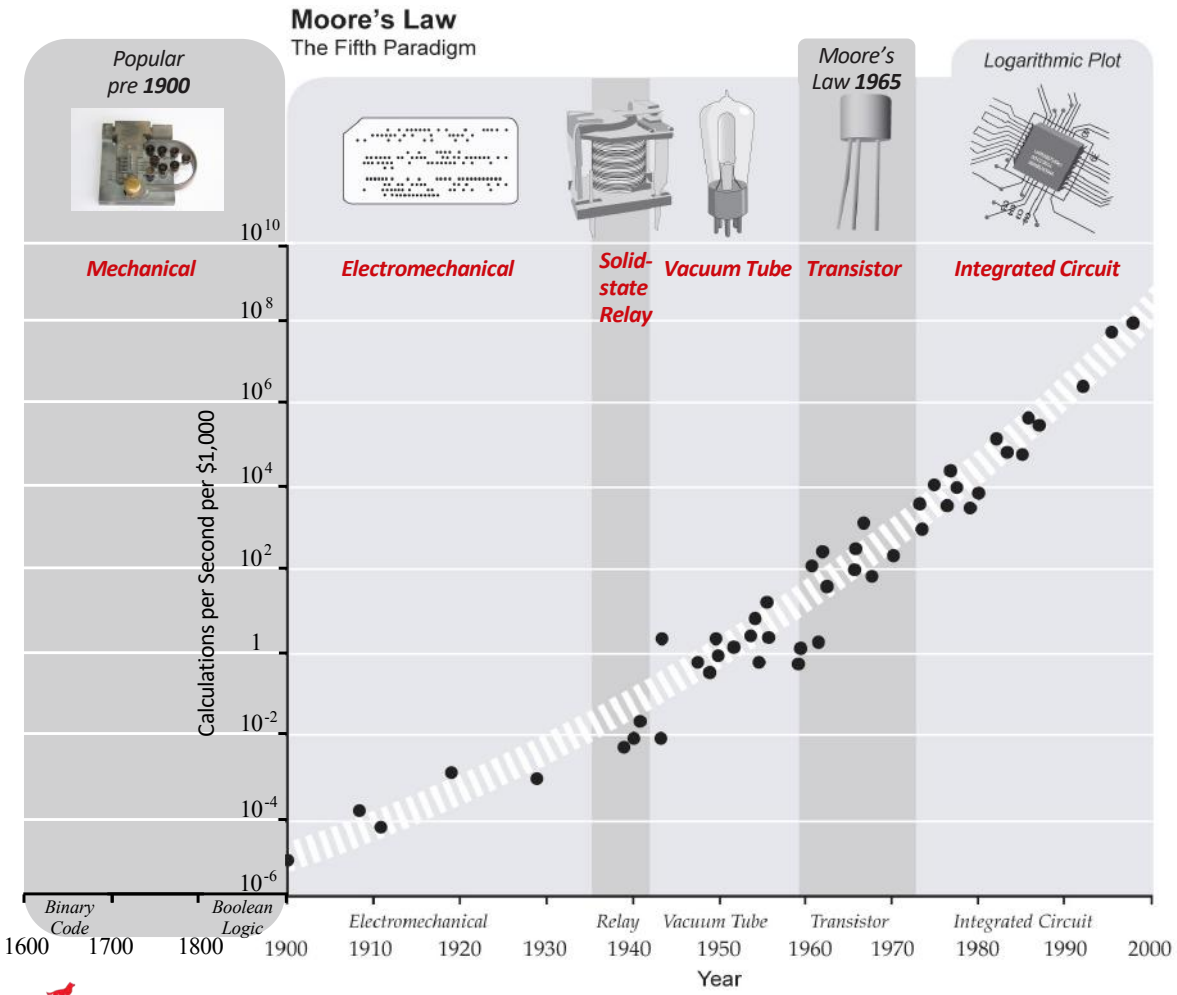

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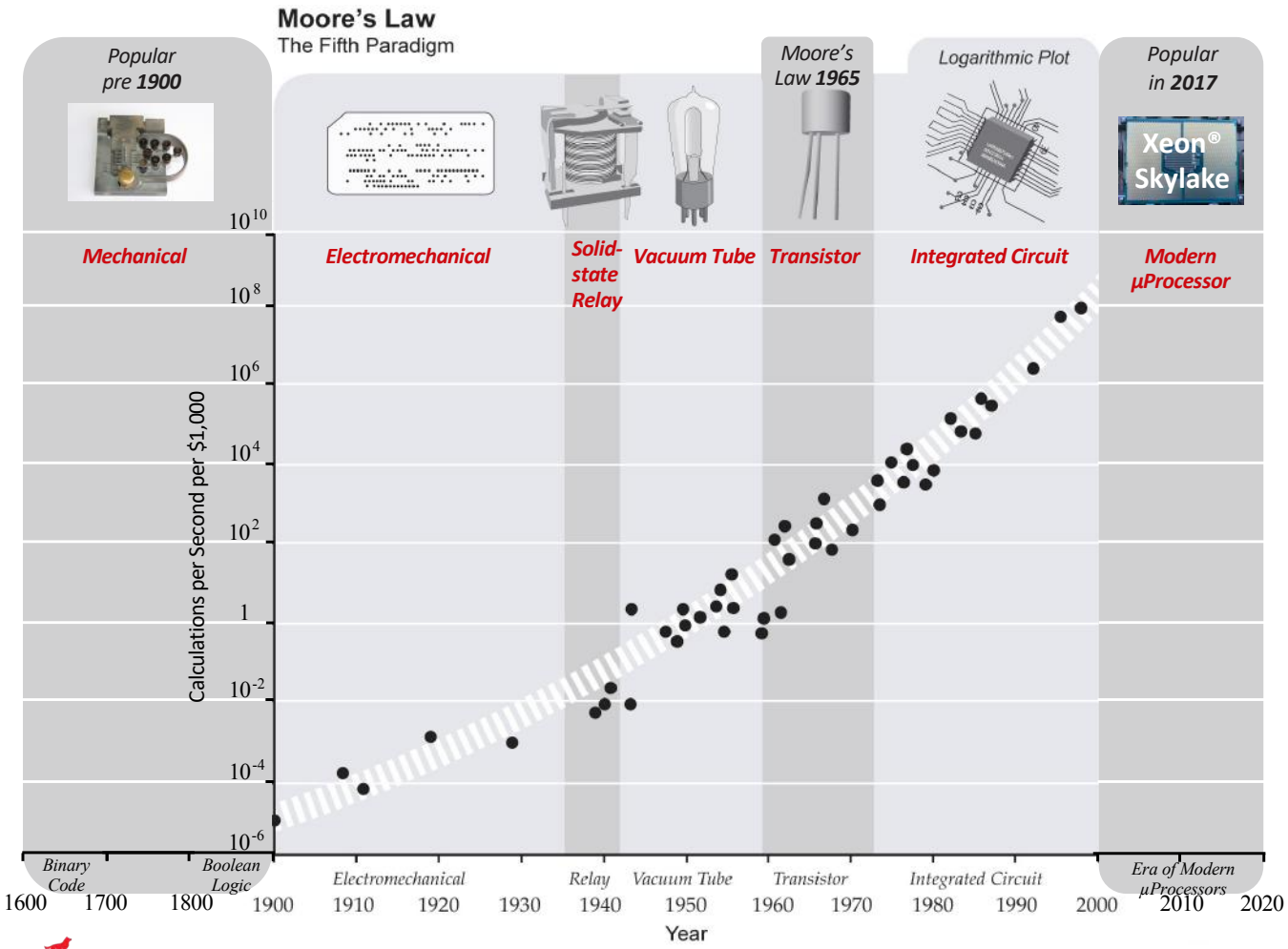
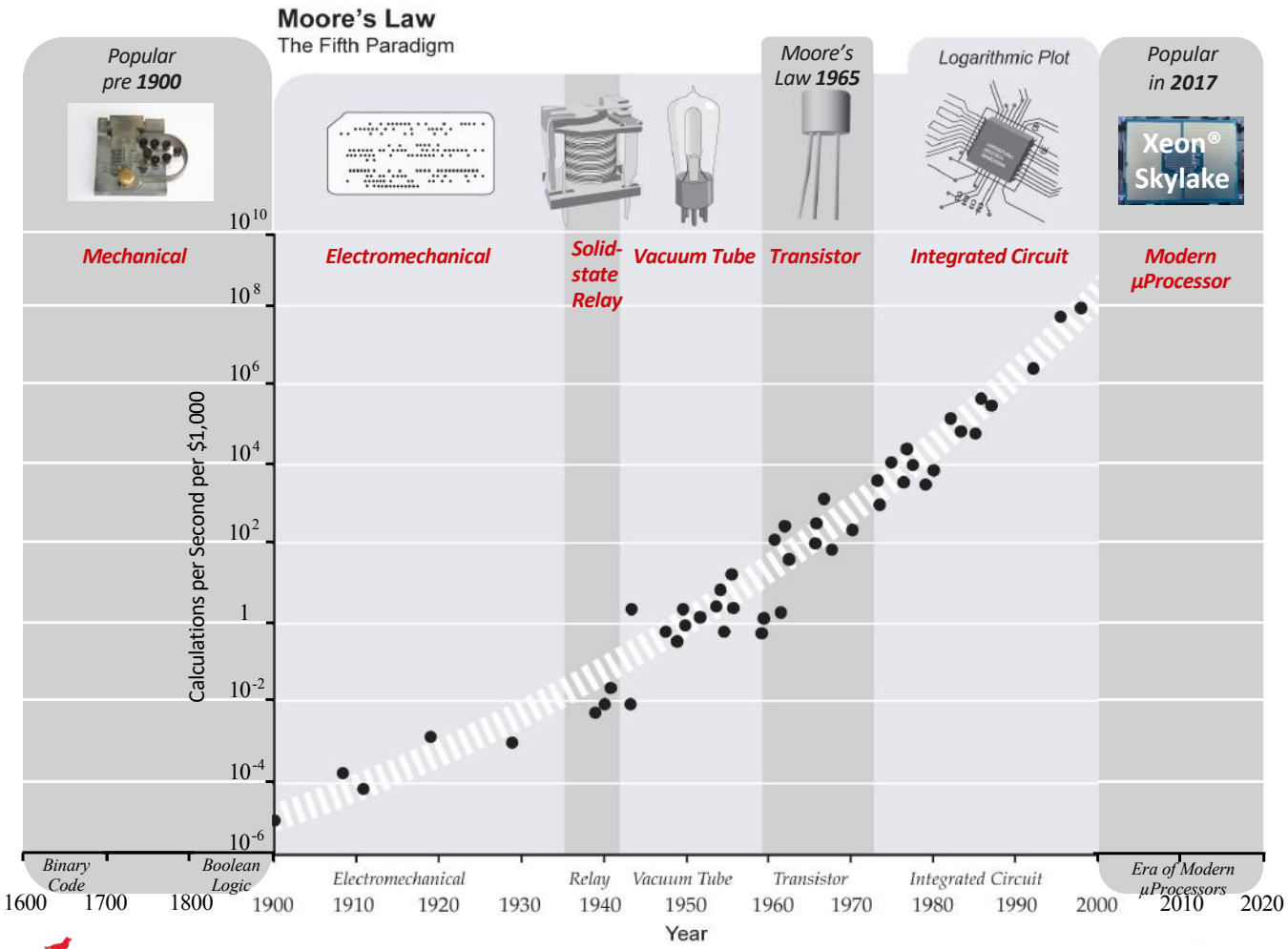


Source: Ray Kurzweil, "The Singularity Is Near: When Humans Transcend Biology", Page 67, The Duckworth Publishers 2009. Data points between 1600 and 1900, and after 2000 represent Maciek's perspective and approximations.

Remember **1965** ”Moore’s Law” – Yes, It Surely Is ..

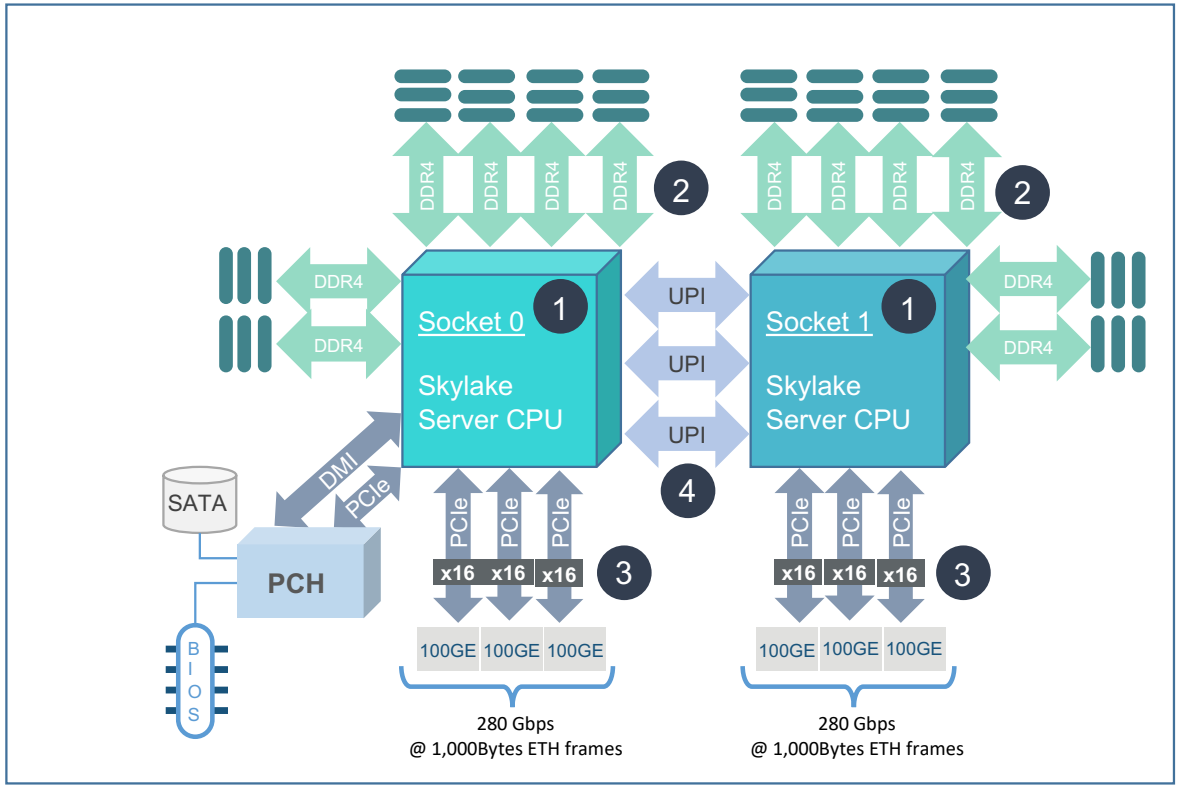
“Ramble On ..”



...

Source: Ray Kurzweil, "The Singularity Is Near: When Humans Transcend Biology", Page 67, The Duckworth Publishers 2009. Data points between 1600 and 1900, and after 2000 represent Maciek's perspective and approximations.

Processing Packets: How to Use Compute ..



$$CyclesPerPacket\ [ClockCycles] = \frac{\#Instructions}{Packet} * \frac{\#Cycles}{Instruction}$$

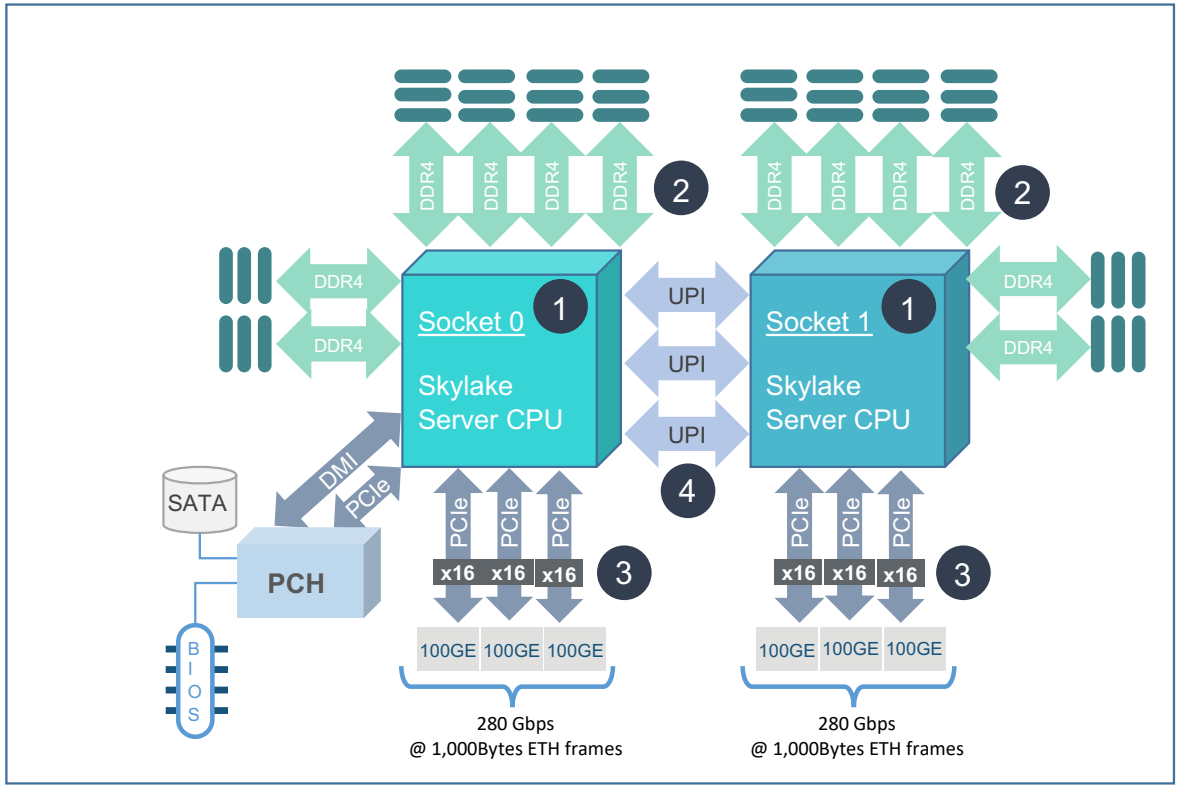
$$Throughput\ [pps] = \frac{1}{Packet\_Processing\_Time[sec]} = \frac{CPU\_freq[Hz]}{Cycles\_per\_Packet}$$

$$Throughput\ [bps] = Throughput[pps] * Packet\_Size[pps]$$

Resources to Get Performance

1. **Processor and CPU cores**
   for performing packet processing operations
2. **Memory bandwidth**
   for moving data (packets, lookup) and instructions (packet processing)
3. **I/O bandwidth**
   for moving packets to/from NIC interfaces
4. **Inter-socket bandwidth**
   for handling inter-socket operations

Processing Packets: What Improves in Compute ..



$$CyclesPerPacket\ [ClockCycles] = \frac{\#Instructions}{Packet} * \frac{\#Cycles}{Instruction}$$

$$Throughput\ [bps] = Throughput[pps] * Packet\_Size[pps]$$

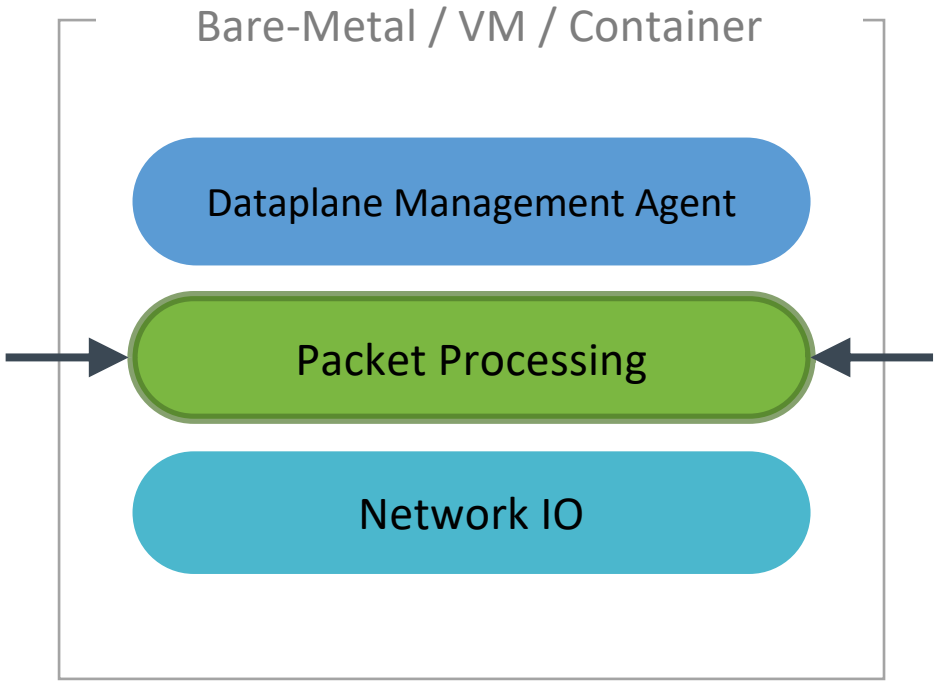
Moore's Law in Action

Resources to Get Performance

1. **Processor and CPU cores**
   ***FrontEnd:* faster** instr. decoder (4- to 5-wide)
   ***BackEnd:* faster** L1 cache, bigger L2 cache, deeper OOO* execution
   Uncore: move from ring to X-Y fabric mesh
2. **Memory bandwidth**
   ***~50% increase**:* channels (4 to 6), speed (DDR-2666)
3. **I/O bandwidth**
   >50% increase: PCIe lanes (40 to 48), re-designed IO blocks
4. **Inter-socket bandwidth**
   ~60% increase: QPI to UPI (2x to 3x), interface speed (9.6 to 10.4 GigTrans/sec)

FD.io VPP – Vector Packet Processing

Compute-Optimised SW Networking Platform



Packet Processing Software Platform

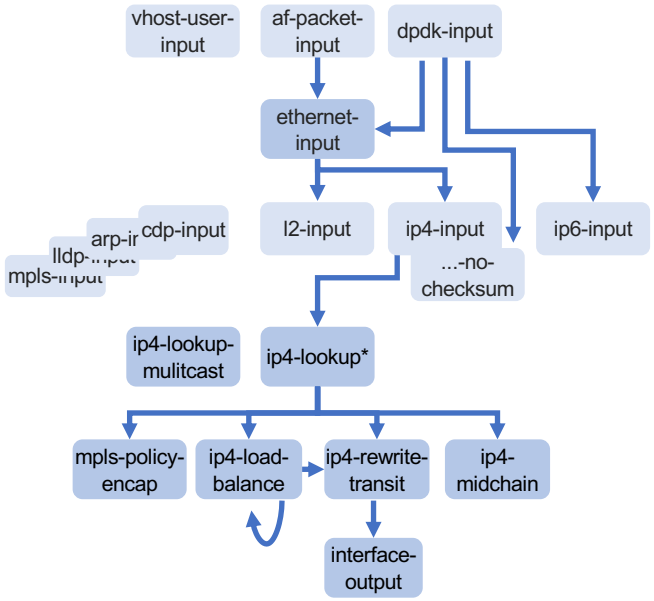
- High performance
- Linux user space
- Runs on compute CPUs:
  - And “knows” how to run them well !

Shipping at volume in server & embedded products

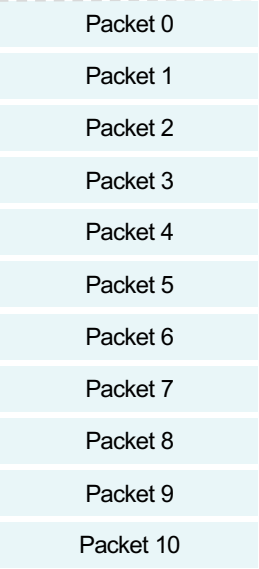
FD.io VPP – The “Magic” of Vectors

Compute Optimized SW Network Platform

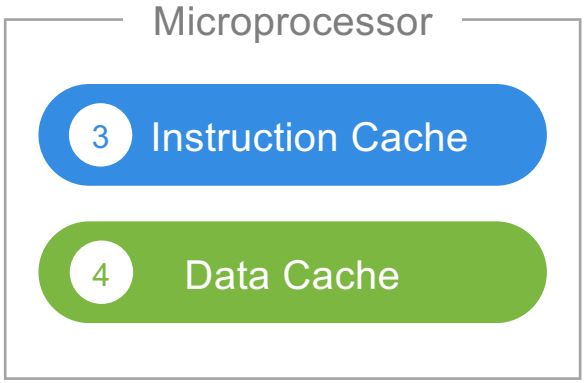
1 Packet processing is decomposed into a directed graph of nodes …



2 … packets move through graph nodes in vector …



3 … graph nodes are optimized to fit inside the instruction cache …



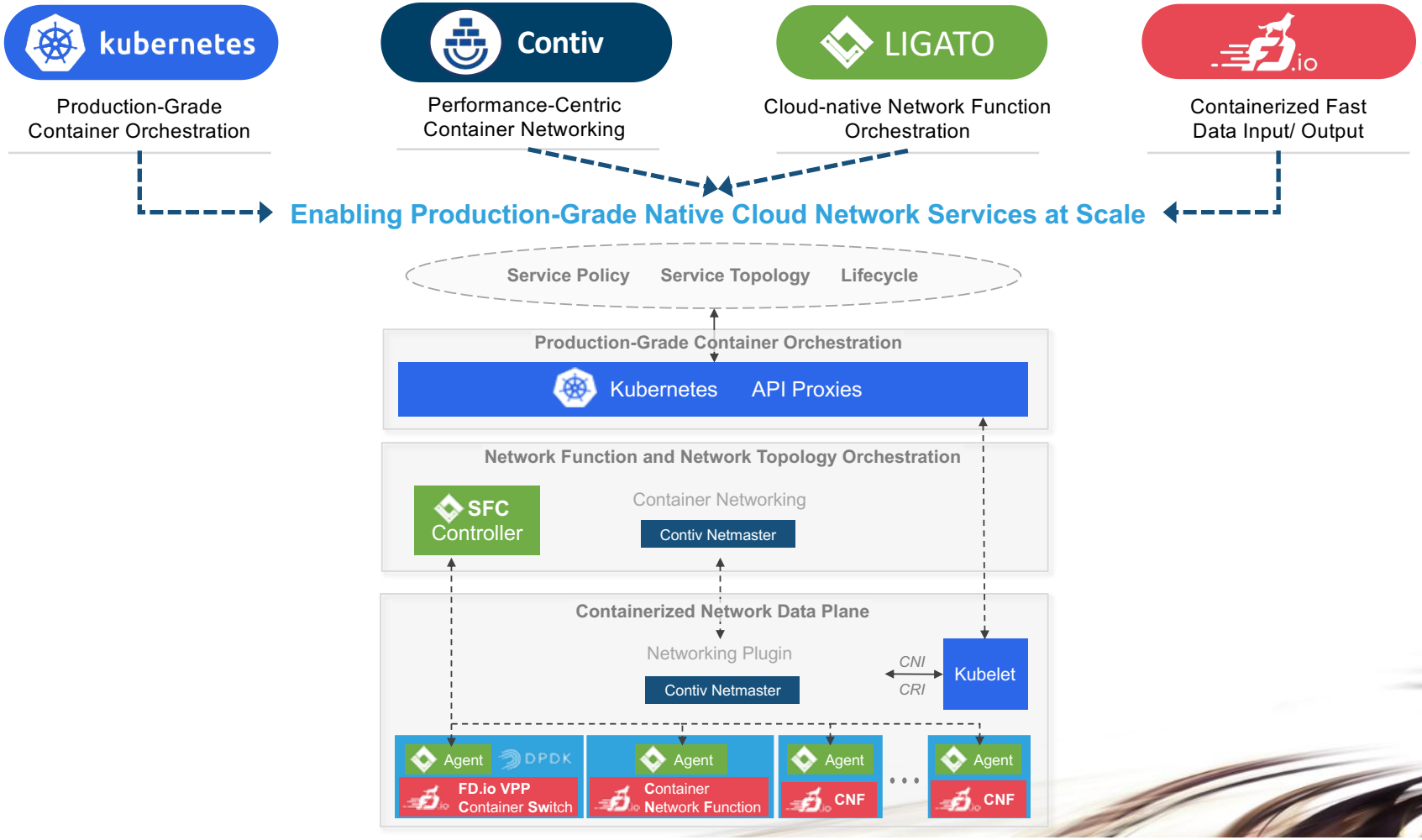
4 … packets are pre-fetched into the data cache.

* Each graph node implements a “micro-NF”, a “micro-NetworkFunction” processing packets.

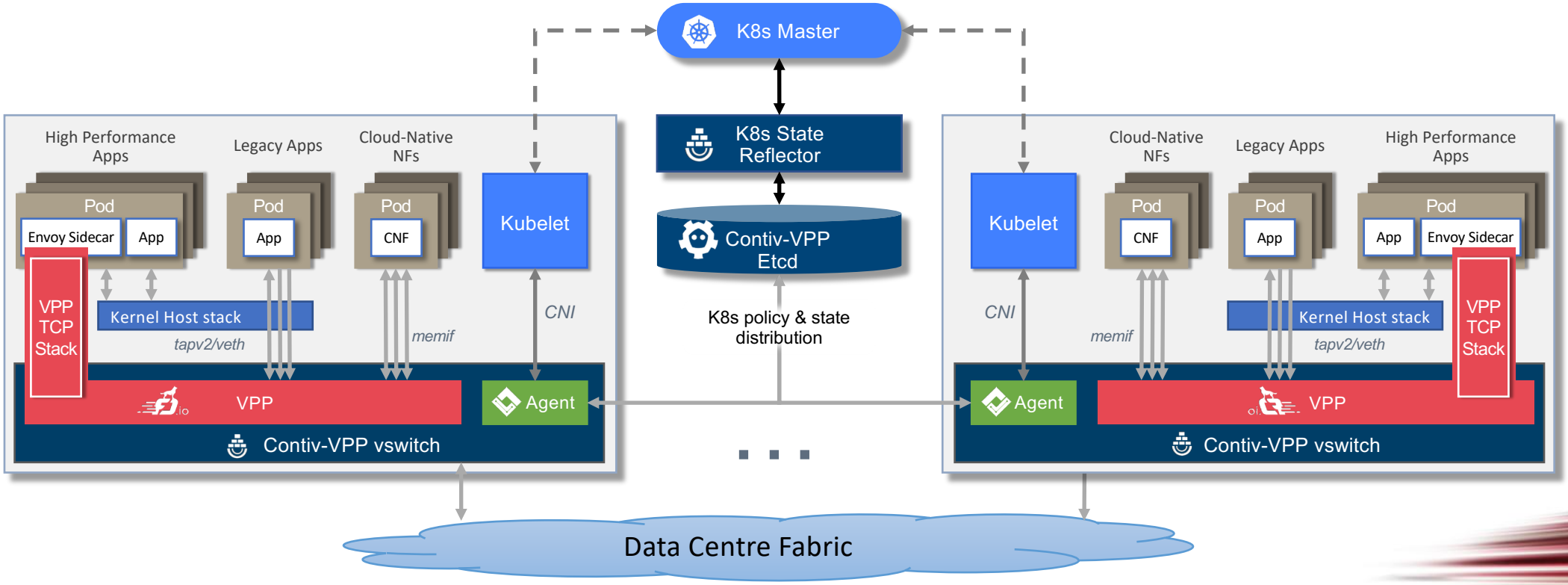
Makes use of modern Intel® Xeon® Processor micro-architectures.
Instruction cache & data cache always hot ➔ Minimized memory latency and usage.

Cloud-native Network Micro-Services

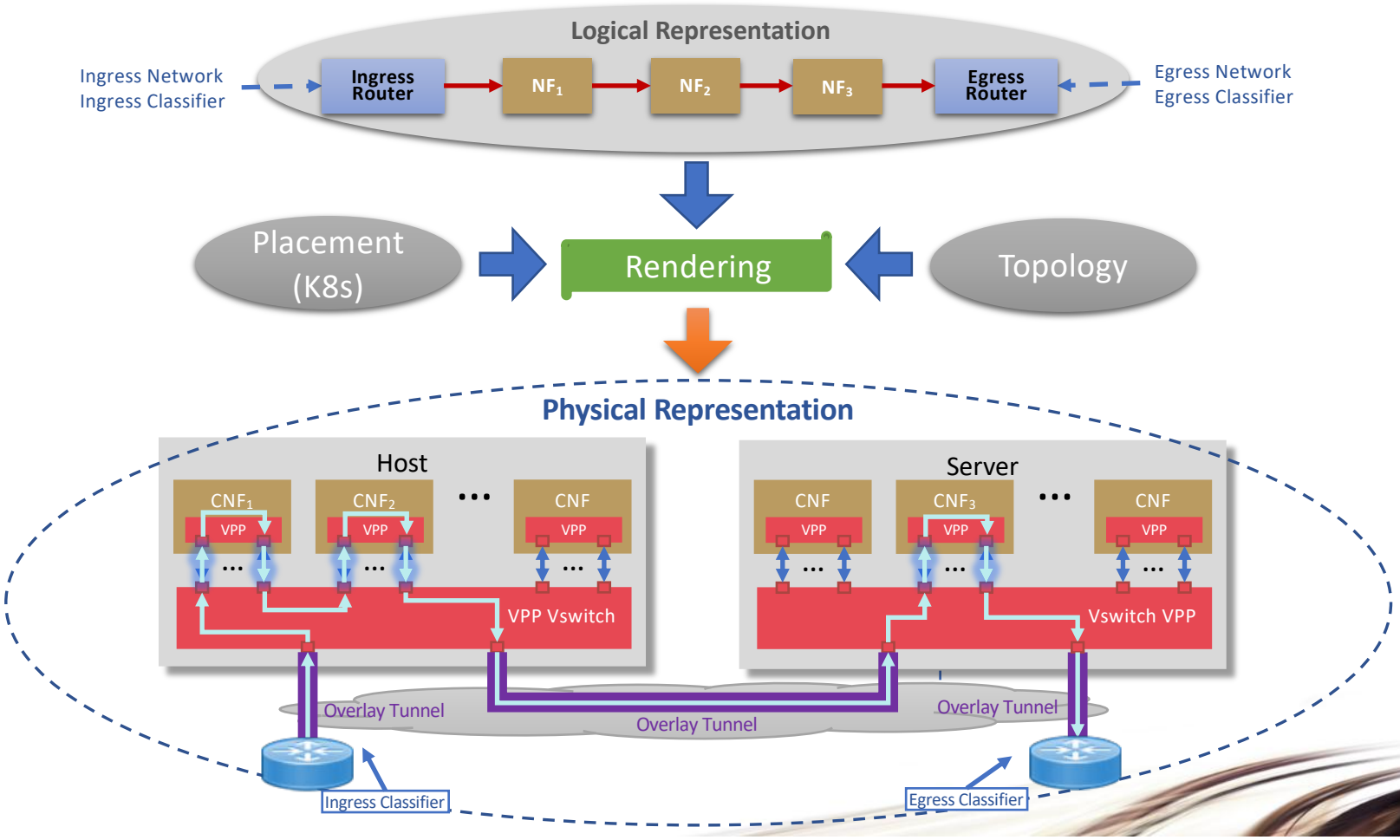
For Native Cloud Network Services



Contiv-VPP Architecture

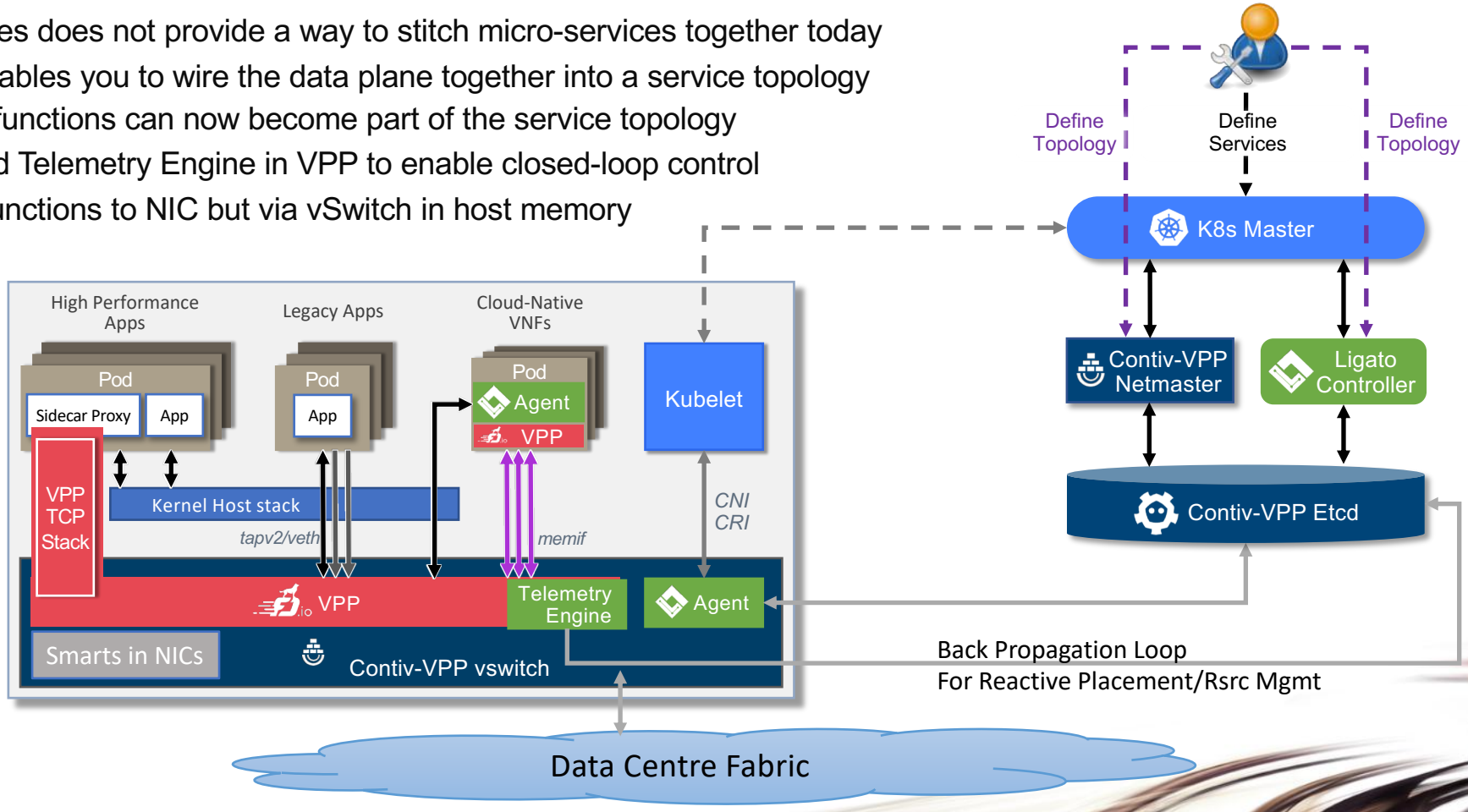


Service Function Chaining with Ligato



Ligato – Cloud-native NFs (CNFs)

- Kubernetes does not provide a way to stitch micro-services together today
- Ligato enables you to wire the data plane together into a service topology
- Network functions can now become part of the service topology
- Dedicated Telemetry Engine in VPP to enable closed-loop control
- Offload functions to NIC but via vSwitch in host memory



“Without data, you're just another person with an opinion.” — W. Edwards Deming

Open Source Benchmarking – Guiding Principles

- Discover the *limits* and *know them*
- Assess based on *externally measured data* and behavior (black-box)
- Guide benchmarking by *good understanding* of the whole system (white-box)
- Provide a feedback loop to hardware and software engineering

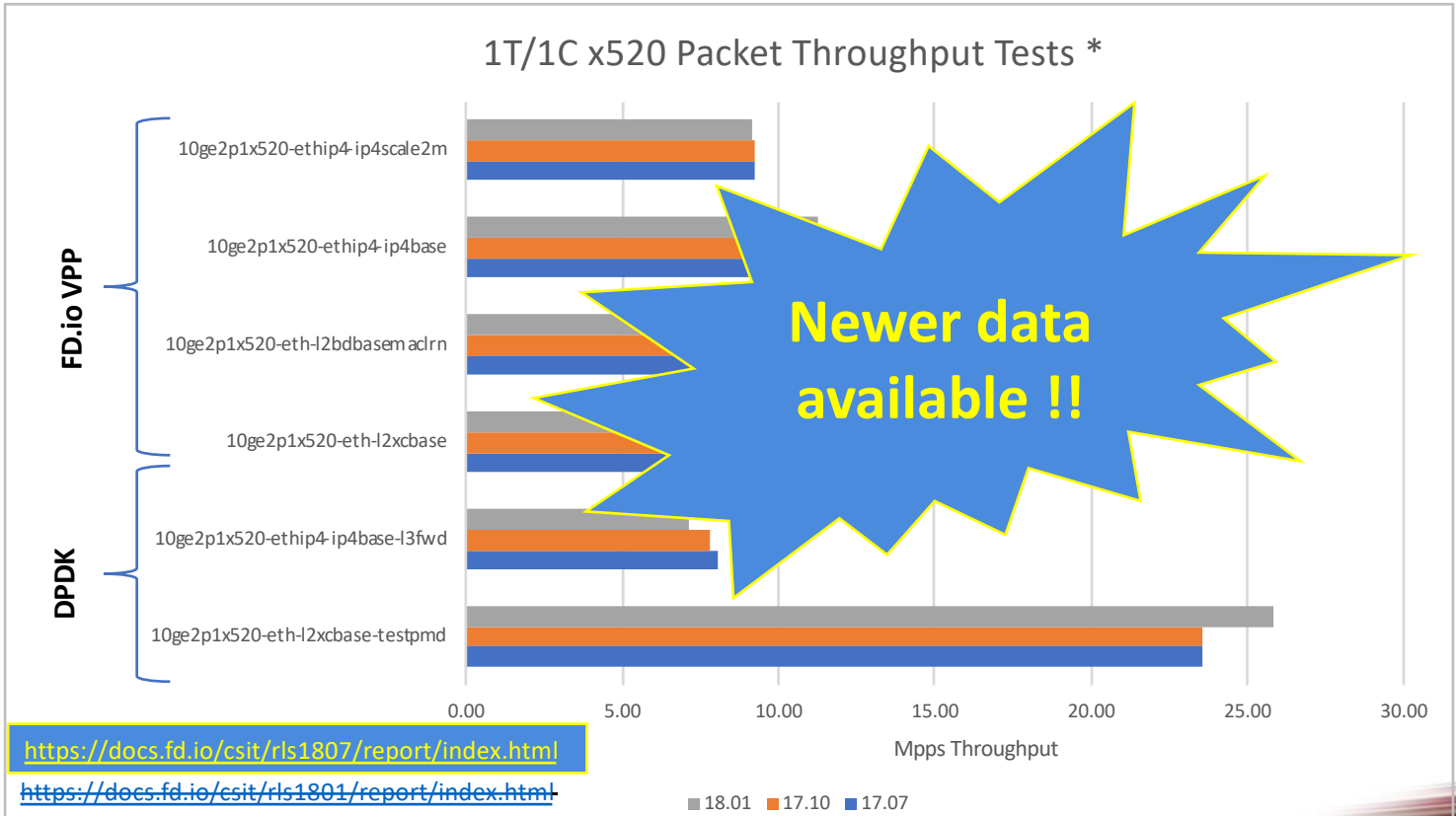
"One can't violate the laws of physics, but one can 'stretch' them.."

Benchmarking Data and Public References:

FD.io CSIT-CPL

Per release test and performance reports

- **Multi-Platform/-Vendor**
  - Intel & ARM (WiP)
- **Packet Throughput & Latency**
  - Non-Drop & Partial Drop Rates
- **Data Plane Workloads**
  - FD.io VPP
  - DPDK L3fwd, Testpmd
- **Scaling**
  - Single-, Multi-Core
  - MACs, IPs, Flows, ACLs etc.
- **Performance Test Suites (#s)**
  - L2: 58
  - L3 (IPv4 / IPv6): 63
  - VM vhostuser: 26
  - Containers memif: 10
  - Crypto: 13
  - SRv6: 3
  - **Total: 173**



https://docs.fd.io/csit/rls1807/report/index.html

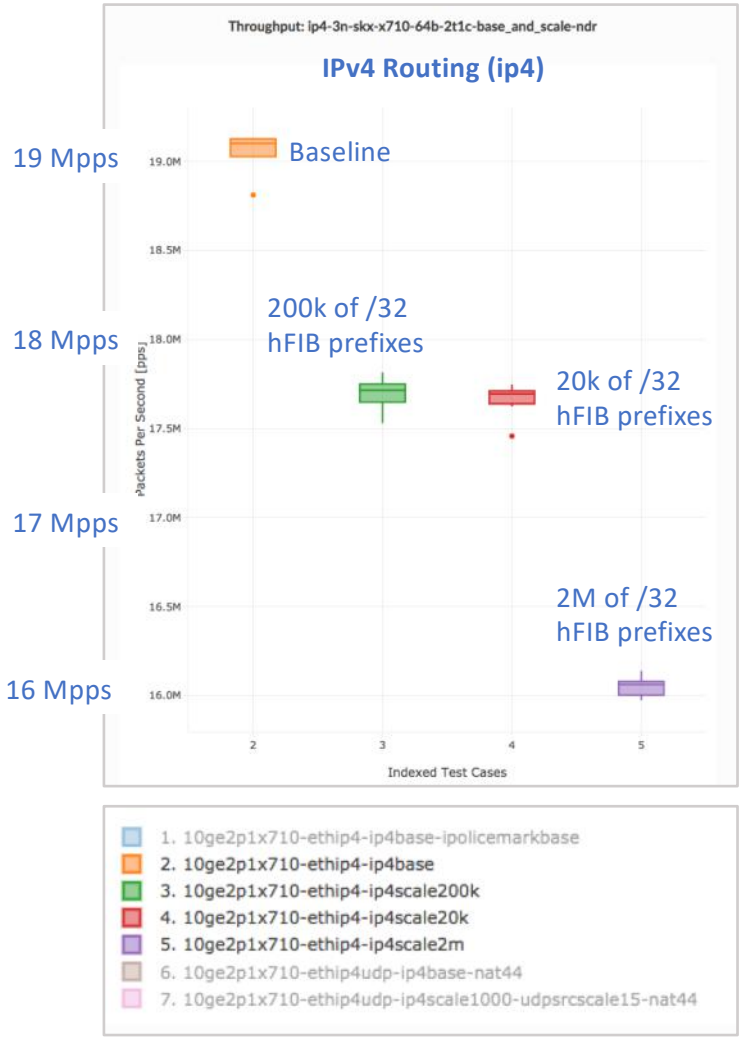
~~https://docs.fd.io/csit/rls1801/report/index.html~~

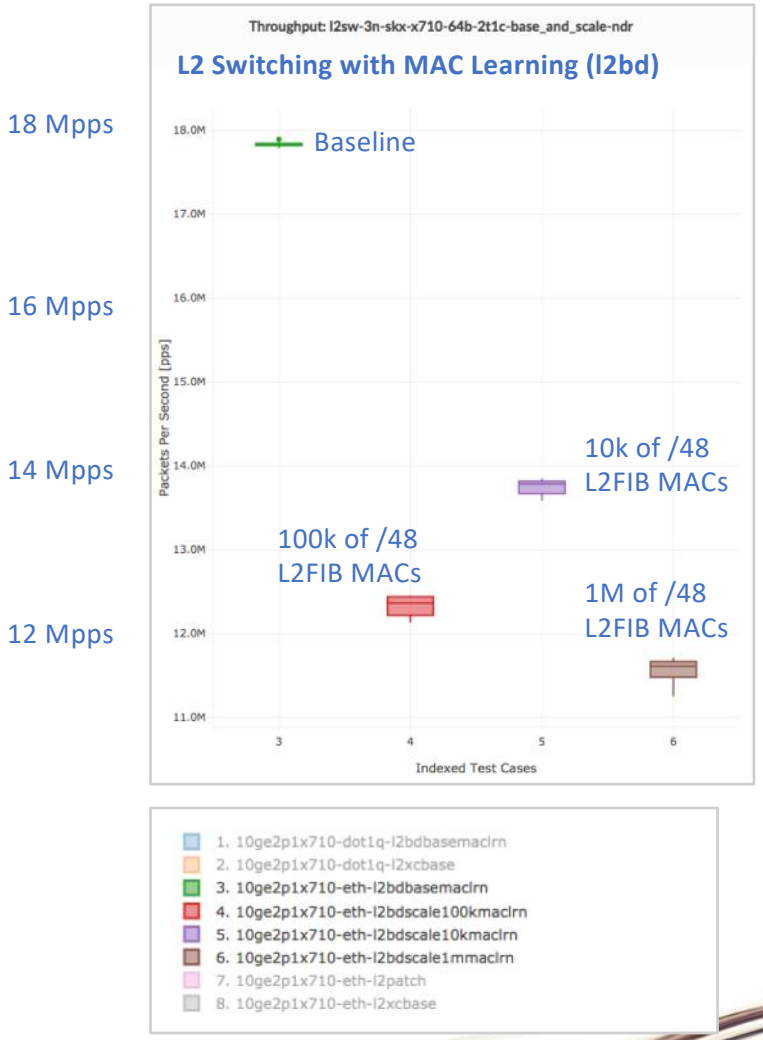
* Selection of testcases from the FD.io CSIT 18.01, 17.10 and 17.07 reports

Breath (# of test cases), **Depth** (of measurement) and **Repeatability** (every release, repeatable locally)

Source: https://docs.fd.io/csit/rls1807/report/

FD.io CSIT-18.07: Packet Throughput Results



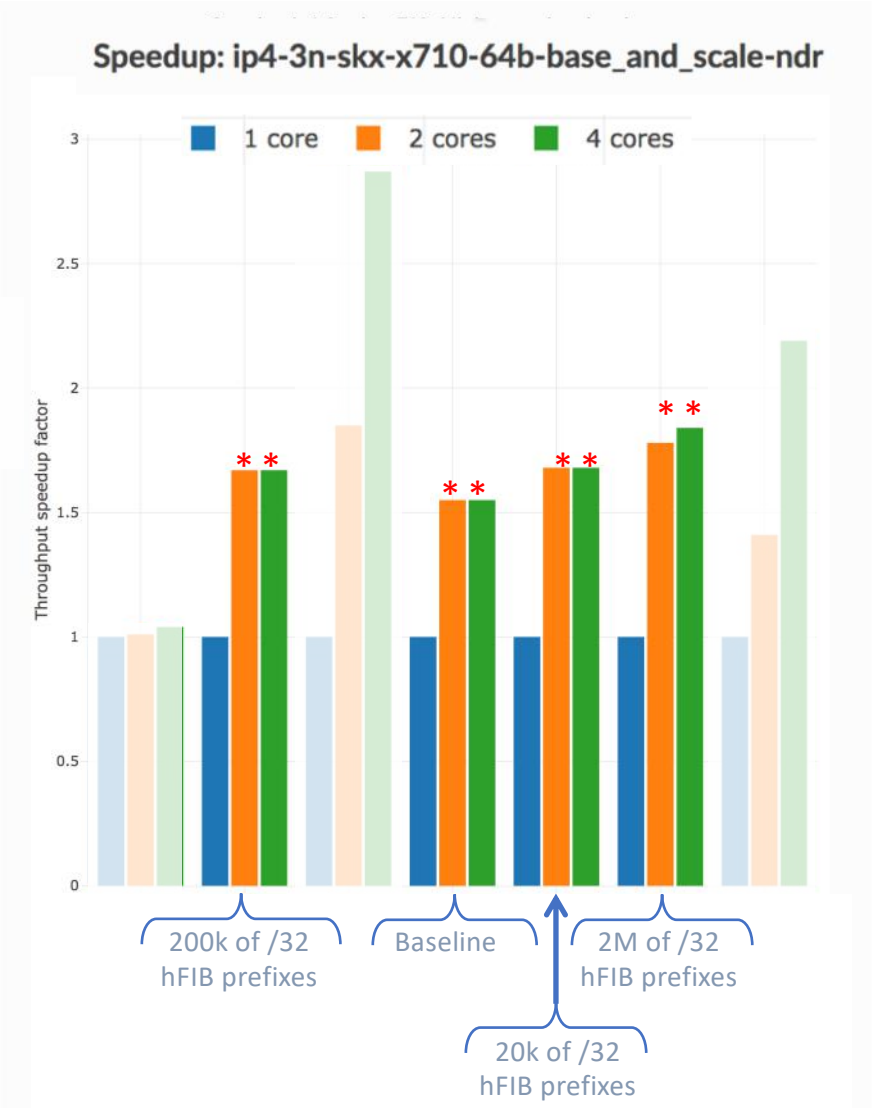


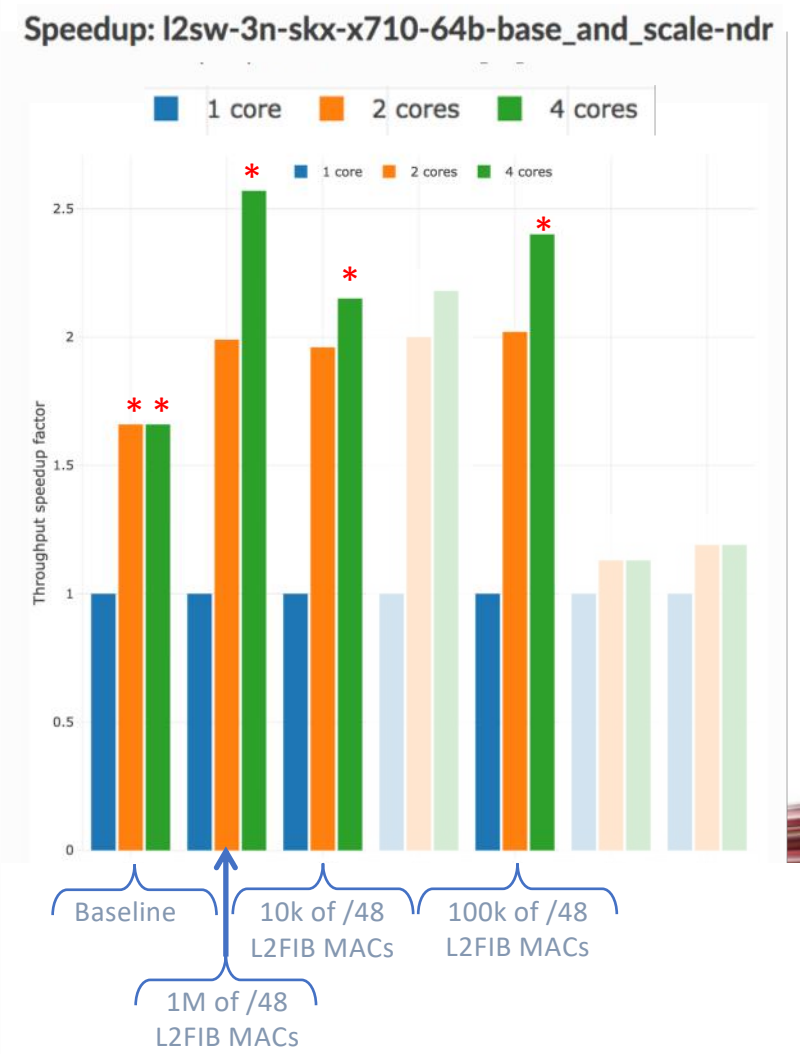
FD.io CSIT-18.07: Throughput Speedup Results

Source: https://docs.fd.io/csit/rls1807/report/

VPP Multi-Core Speedup Properties:

- Predictable performance
- Linear scaling with cores
- Follows Amdahl's Law





* Capped by 14.88 Mpps 10GE 64B link rate limit

VPP: Multi-Core Speedup Properties

Source: https://fd.io/wp-content/uploads/sites/34/2018/01/performance_analysis_sw_data_planes_dec21_2017.pdf

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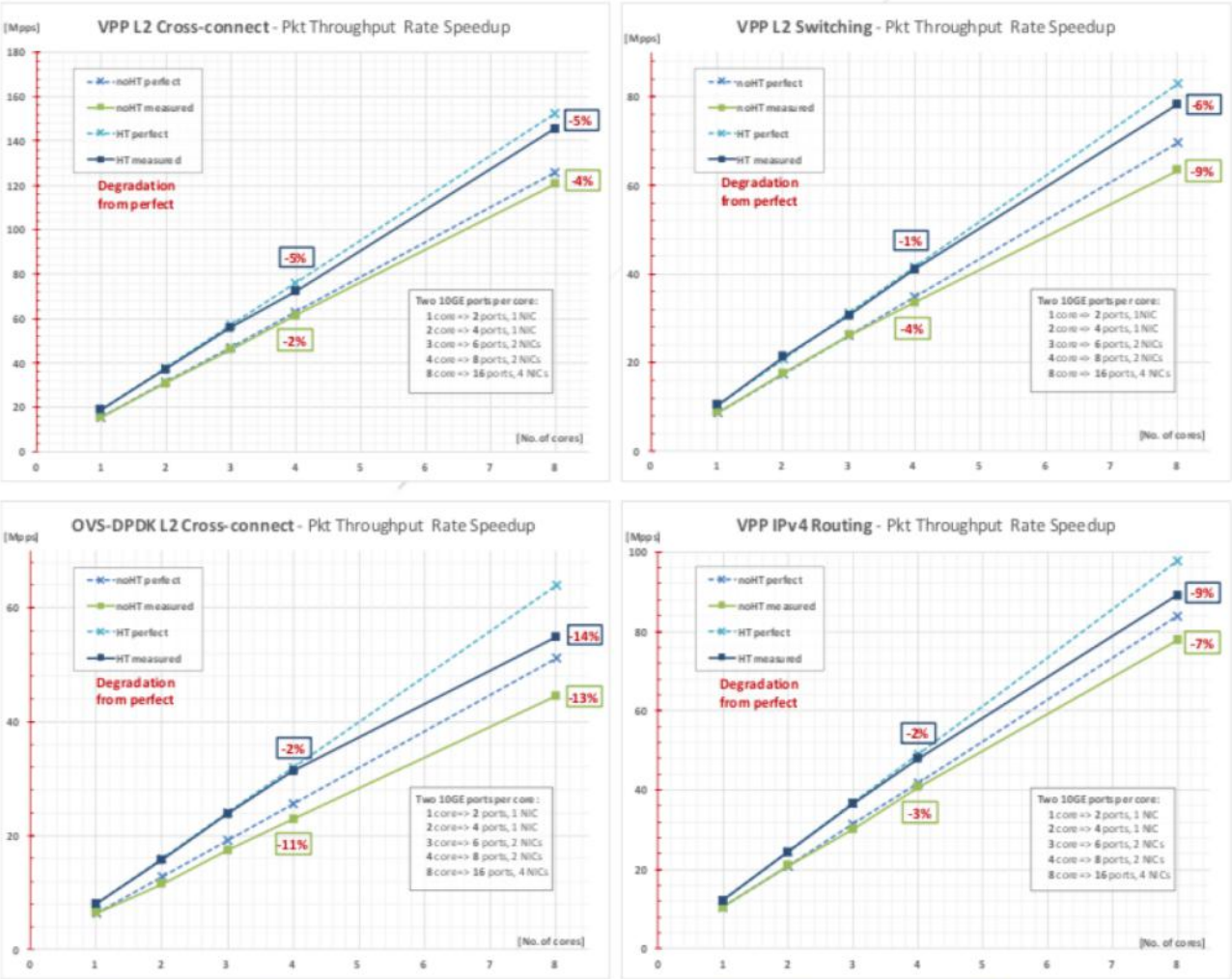
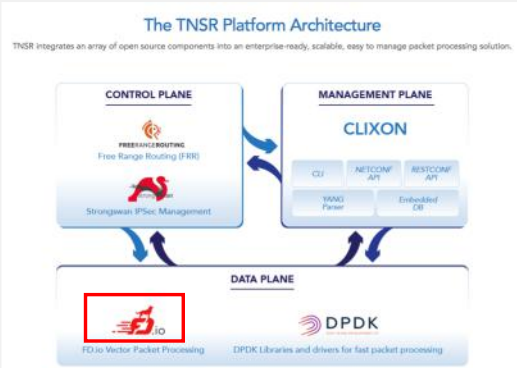


Figure 14. Packet throughput speedup with Multithreading and Multi-core.

Packet Vectors are Good for You !

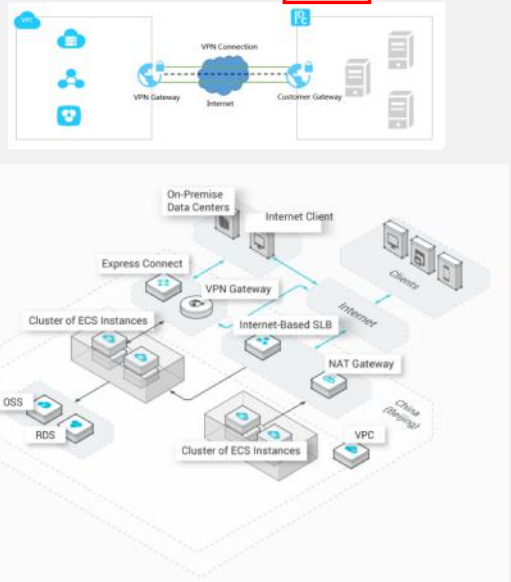
Netgate shipping product(s) [1]

Netgate: TNSR, hw appliances



Alibaba [2]

Alibaba: Network Service Optimization with the VPP Platform



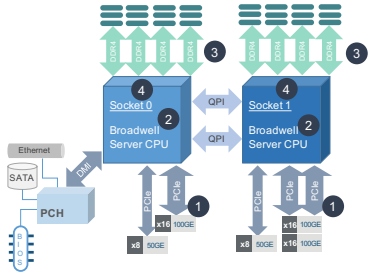
...

[1] https://www.netgate.com/products/tnsr/
[2] https://www.alibabacloud.com/blog/network-service-optimization-with-the-vpp-platform_593985

Baremetal Data Plane Performance Limit

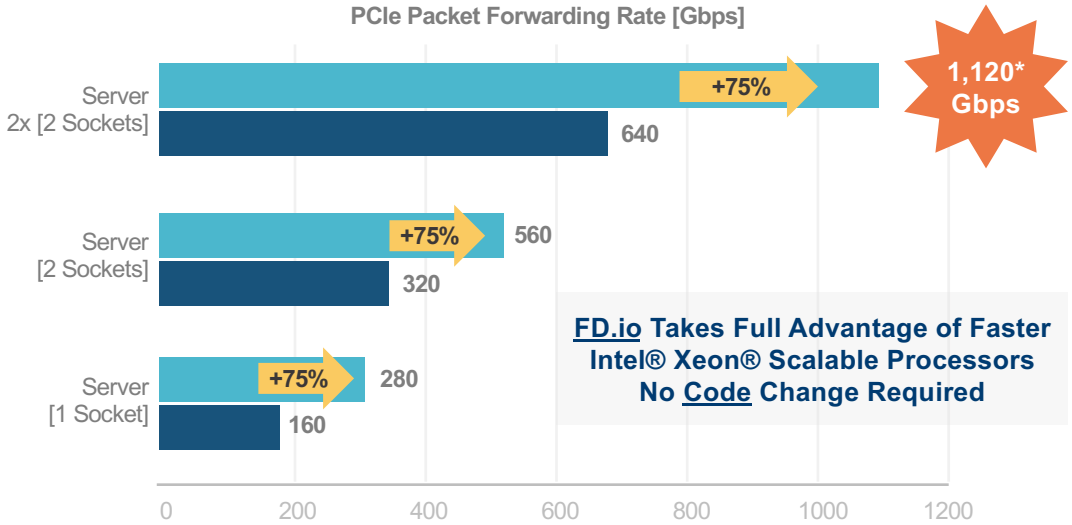
FD.io benefits from increased Processor I/O

YESTERDAY



1. Network I/O: **160 Gbps**
2. Core ALU: **4-wide** parallel µops
3. Memory: **4-channels** 2400 MHz
4. Max power: **145W** (TDP)

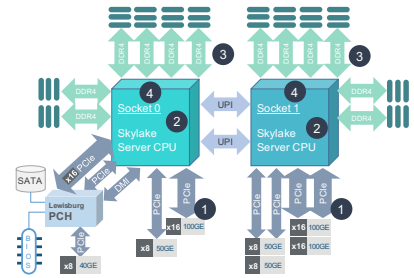
Intel® Xeon® E5-2699v4
22 Cores, 2.2 GHz, 55MB Cache



FD.io Takes Full Advantage of Faster Intel® Xeon® Scalable Processors
No Code Change Required

* On compute platforms with all PCIe lanes from the Processors routed to PCIe slots.

TODAY



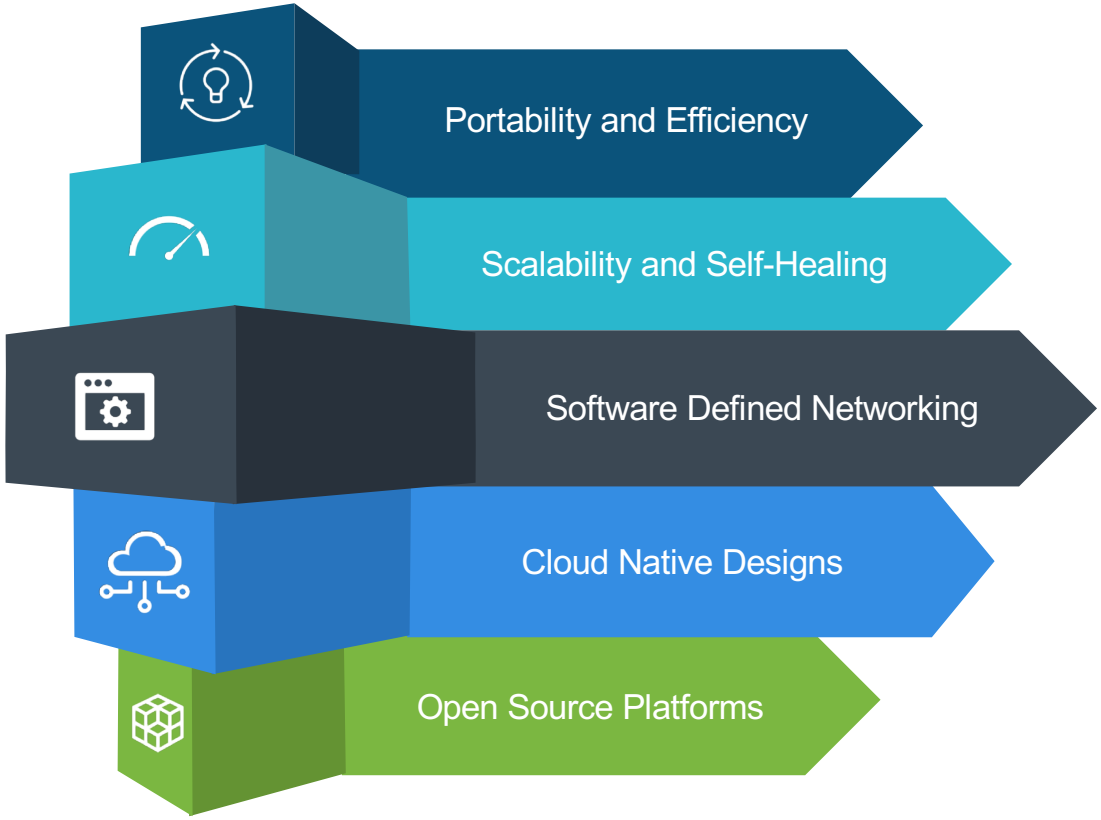
1. Network I/O: **280 Gbps**
2. Core ALU: **5-wide** parallel µops
3. Memory: **6-channels** 2666 MHz
4. Max power: **205W** (TDP)

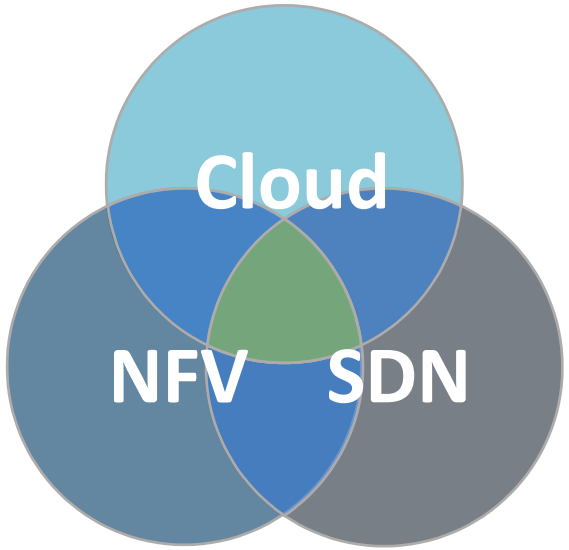
Intel® Xeon® Platinum 8168
24 Cores, 2.7 GHz, 33MB Cache

https://goo.gl/UtbaHy

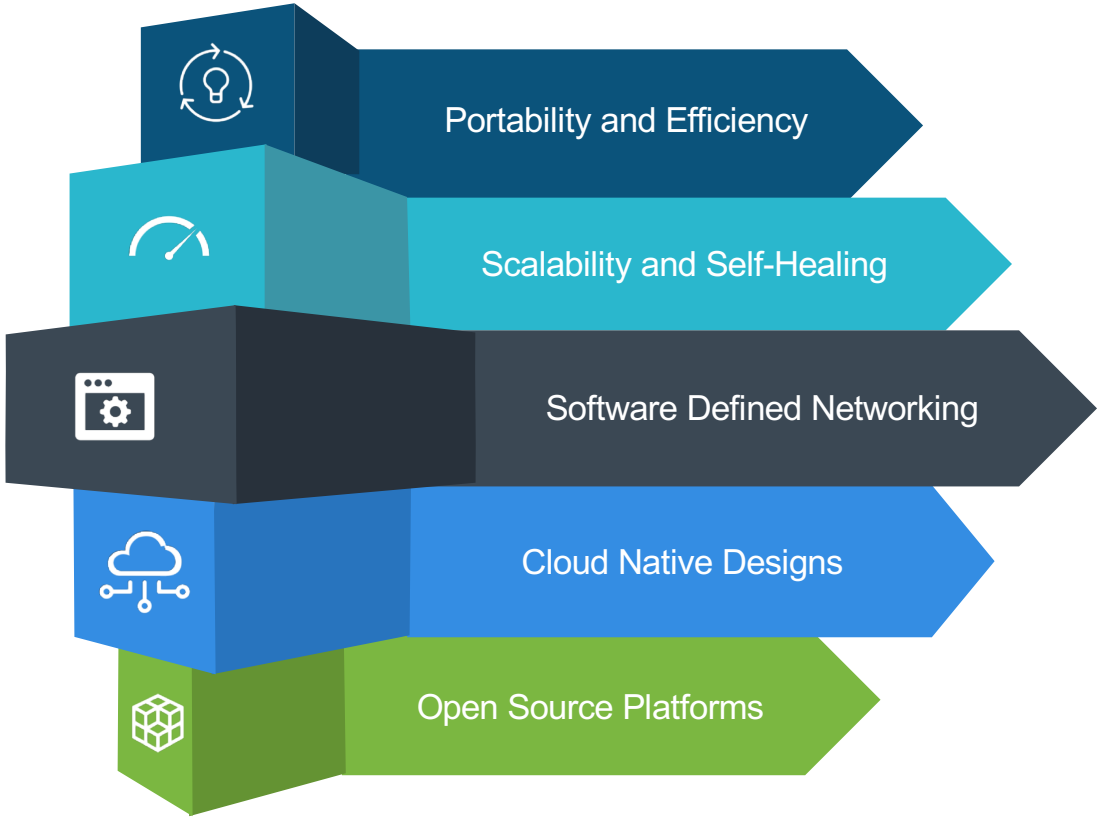
Breaking the Barrier of Software Defined Network Services
1 Terabit Services on a Single Intel® Xeon® Server !

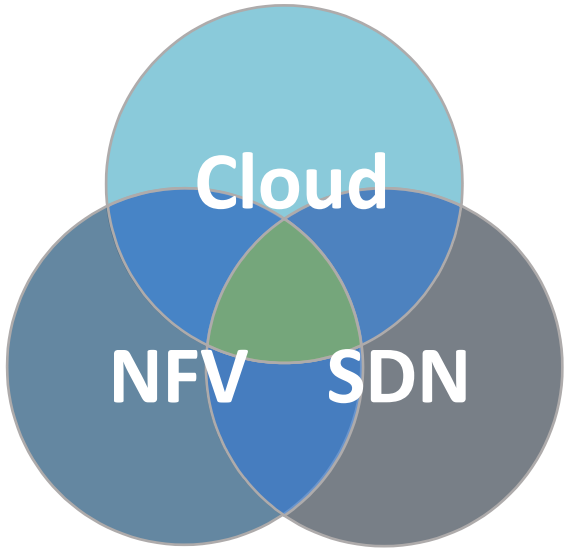
Internet Mega Trends – ..



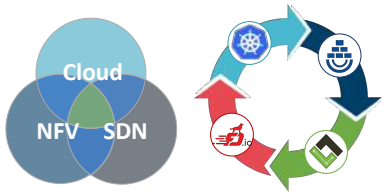


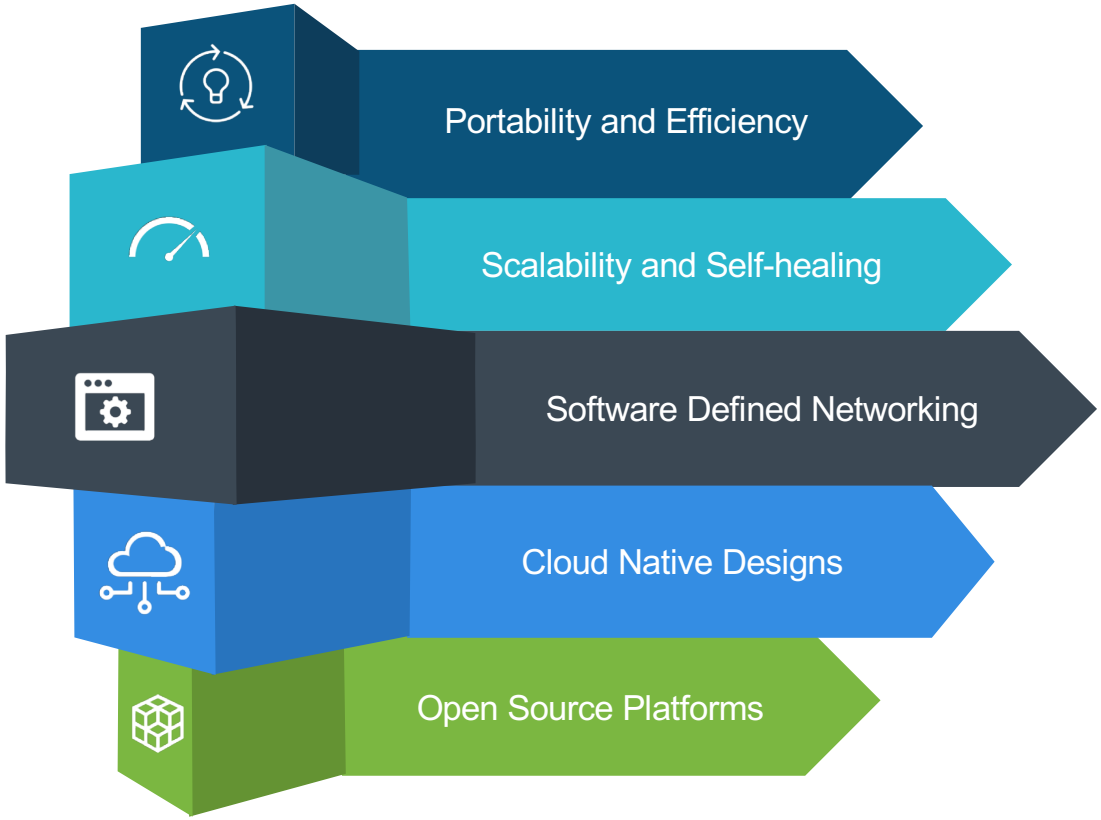
Internet Mega Trends – *Being* Addressed ..





Internet Mega Trends – *Being* Addressed ..





PORTABILITY AND EFFICIENCY

Public, private, hybrid, any-cloud. Over 10 times faster Container networking vs. alternatives.

SCALABILITY and SELF-HEALING

Follows Kubernetes scale and self-healing principles.

SOFTWARE DEFINED NETWORKING

FD.io VPP, the Fastest SW Data Plane on the Planet. Over 200 programmable "micro-NFs" and plugins.

CLOUD NETWORK SERVICES

Containerized NFs managed as true cloud-native apps, provide and consume dat plane microservices.

LINUX FOUNDATION

Based on the best-of-breed collaborative projects in Linux Foundation.

ons
EUROPE
OPEN NETWORKING //
Integrate, Automate, Accelerate

September 25 - 27, 2018
Amsterdam, The Netherlands

High Performance Cloud-Native Networking

K8s Unleashing FD.io

THANK YOU !

References

FD.io VPP, CSIT and related projects

- VPP: https://wiki.fd.io/view/VPP
- CSIT-CPL: https://wiki.fd.io/view/CSIT
- pma_tools - https://wiki.fd.io/view/Pma_tools

Benchmarking Methodology

- Kubecon Dec-2017, Benchmarking and Analysis.., https://wiki.fd.io/view/File:Benchmarking-sw-data-planes-Dec5_2017.pdf
- “Benchmarking and Analysis of Software Network Data Planes” by M. Konstantynowicz, P. Lu, S.M. Shah, https://fd.io/resources/performance_analysis_sw_data_planes.pdf

Opportunities to Contribute

We invite you to Participate in FD.io

- Get the Code, Build the Code, Run the Code
- Try the vpp user demo
- Install vpp from binary packages (yum/apt)
- Read/Watch the Tutorials
- Join the Mailing Lists
- Join the IRC Channels
- Explore the wiki
- Join FD.io as a member

Thank you!