LEVERAGING 400 GBE

Improving Network Economics While Driving Performance

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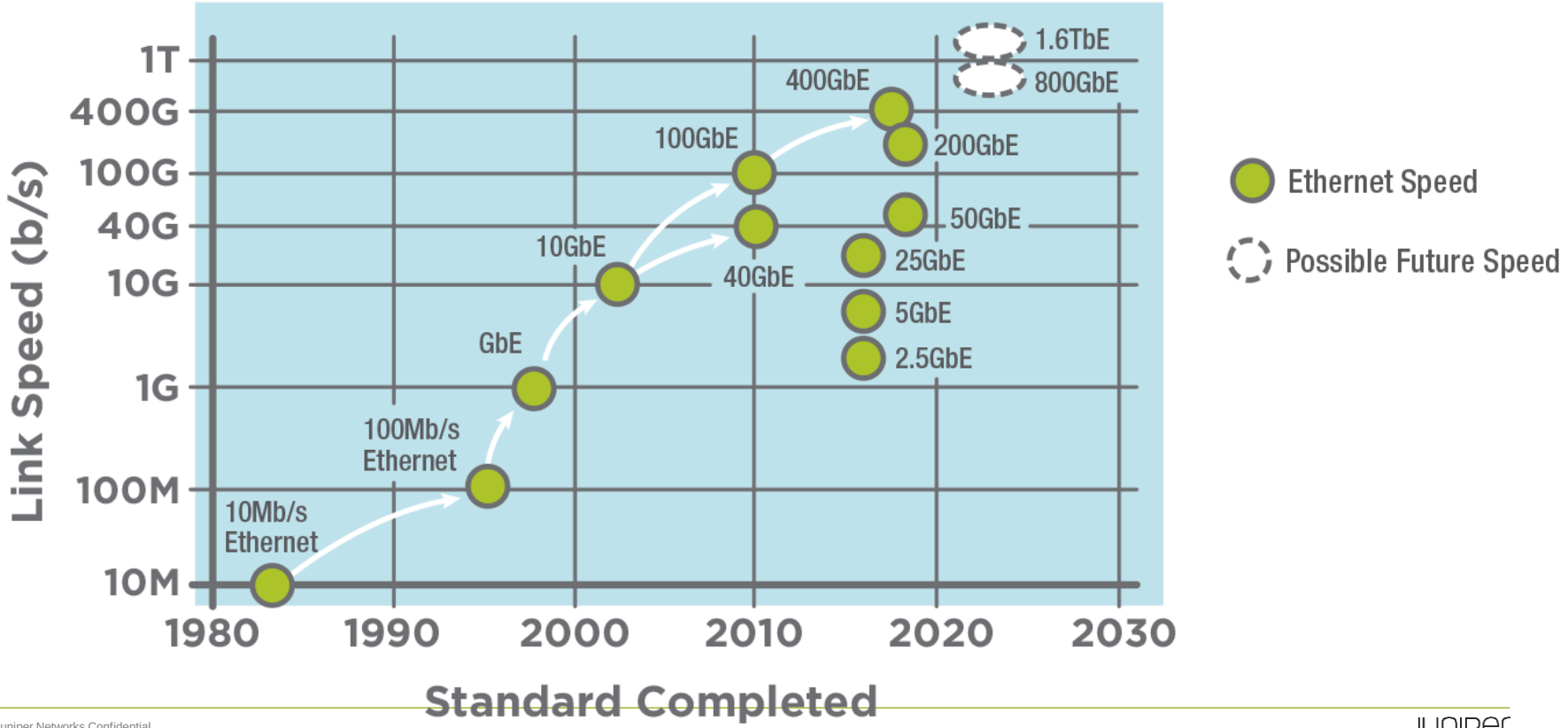
JET Meeting

May 21, 2019

ETHERNET SPEEDS



DRIVERS FOR 400GBE

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WHAT DRIVES JUNIPER'S SOLUTIONS FOR R&E NETWORKS?

The drivers for the solutions we position, and I evangelize, for R&E networks come from other markets.

Fast/Reliable/Low Cost Routers (Carriers)*

IPv6 (Carriers)

Multicast (Wall Street)

Express Path on Firewalls (Wall Street)

perfSONAR (read 3rd party apps) on routers and switches (Social Media)

Node Slicing in R&E Peering Points (Carriers)

400 GE for R&E Networks (Datacenters)

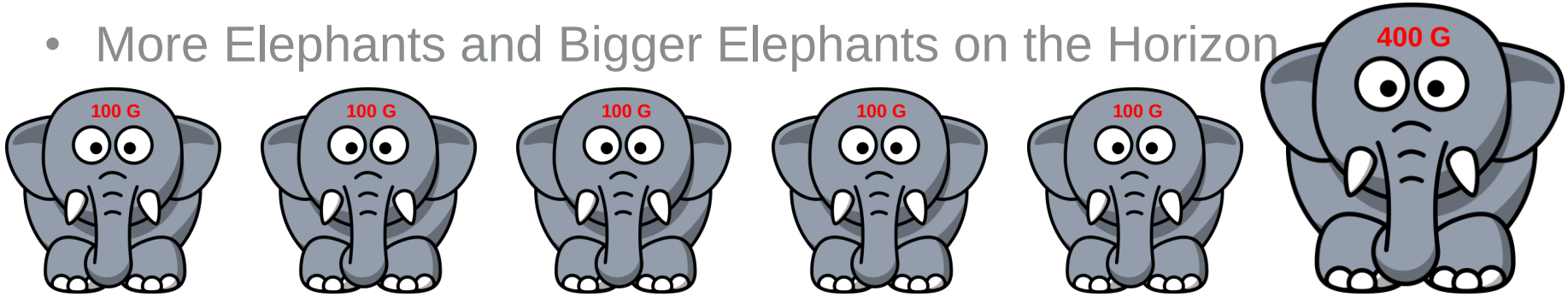
TRENDS DRIVING 400 GE UPTAKE IN DATA CENTERS

- High Compute Intensive Applications to be run extremely fast on parallel clusters
- Proliferation of Devices resulting in exponential growth of internet data traffic
- Enterprise workloads (Compute and Collaboration)
- Consumer workloads (Video Streaming and Social Networking)
- Digital Transformation of businesses across the entire global spectrum
- Data Center Applications Requirements of HyperScalars:
  - Facebook relies on improved User Experience in spite of ever-growing traffic
  - Amazon relies on Cost control – Minimum Cost incurred per Gigabyte of internet traffic
  - Google, Baidu, Alibaba and Tencent – All rely on Faster Response to queries

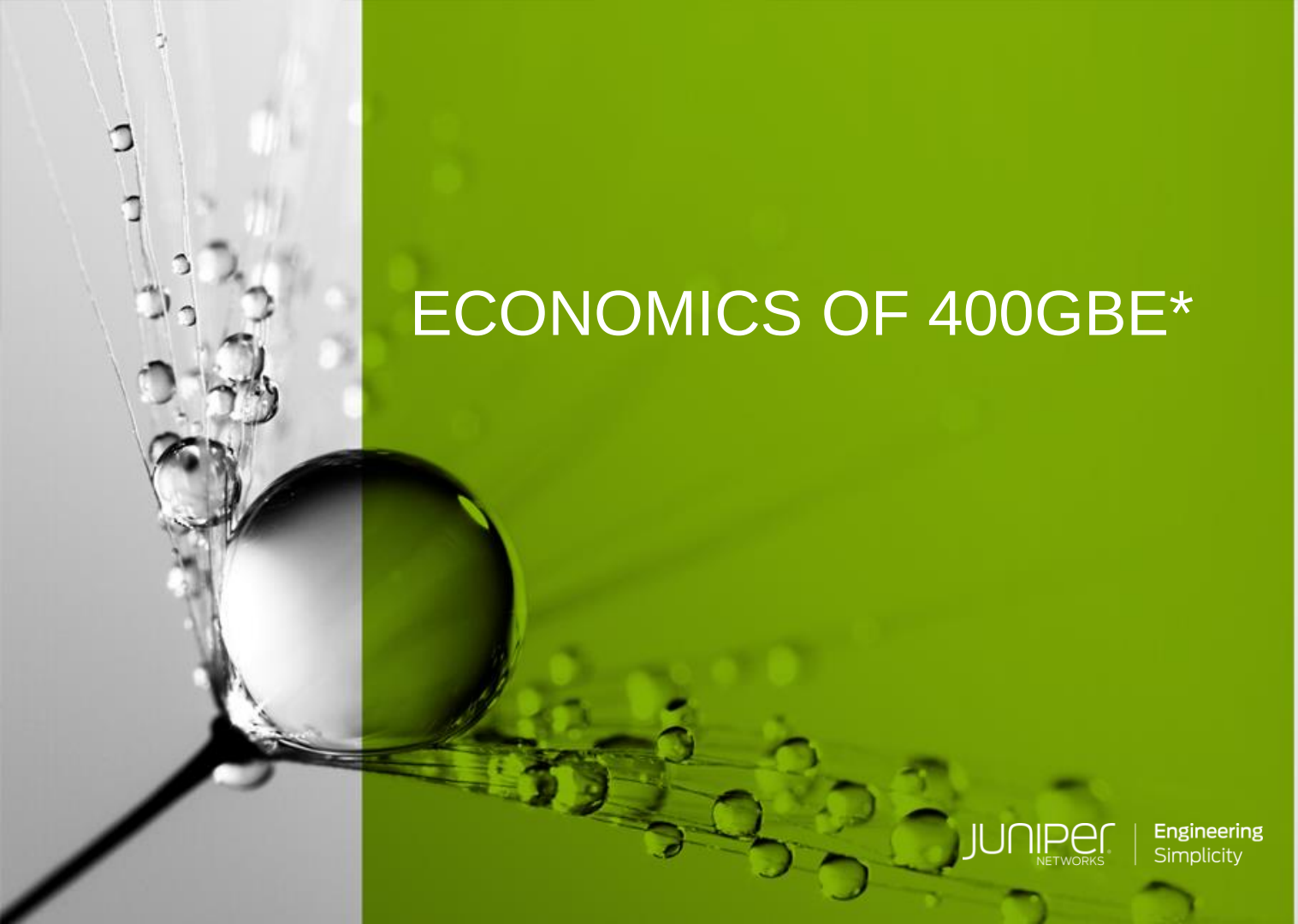
Rapid Adoption Forecast: A Dell' Oro Research Report forecasts 400G to comprise 20% of data-center switching revenue by 2020*

TRENDS THAT WILL BE DRIVING 400GE UPTAKE IN R&E

- Elephant Flows
- Massive instruments dumping ridiculous amounts of data where the preference is not to process locally*
- Massive instruments dumping ridiculous amounts of data that is to expensive to process locally
- Proliferation of Science DMZs and DTNs
- More Elephants and Bigger Elephants on the Horizon



ECONOMICS OF 400GBE*



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WITH OPTICS ECONOMIES OF SCALE ARE NOT COMPELLING

- Traditionally, Costs of Optical Transceivers driven down solely by Volume Economies of Scale. Suppliers Depend on Demand for more optics to drive down costs.
- In contrast, 100 times larger silicon chip supply chain benefited from shared
  - design methodologies
  - automated wafer manufacturing
  - shared packaging approaches
  - common test infrastructure

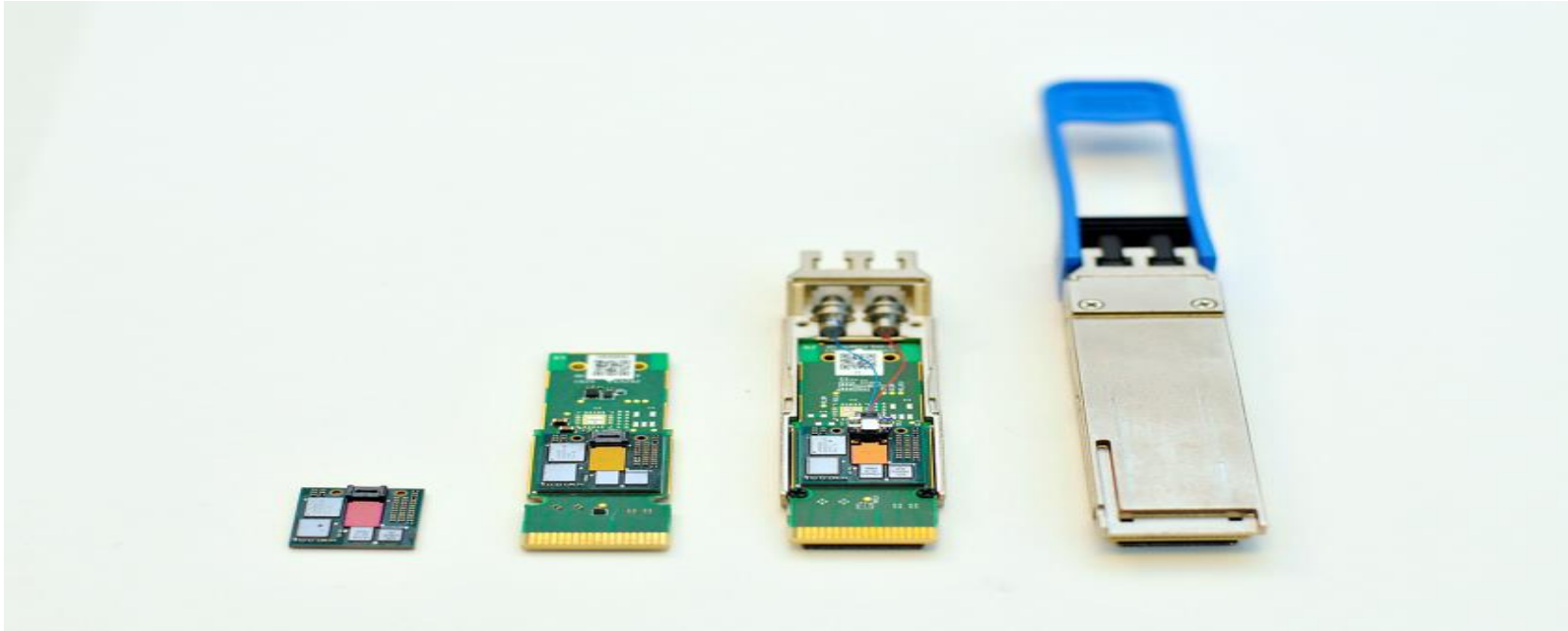
  to deliver unparalleled economies of scale for computing and networking equipment. (Moore's Law)
- Juniper has been successful in lowering cost per bit of its own product portfolio, but dependent on vendors to lower cost of optical interconnects.
- So Juniper acquired Aurrion Inc. in 2016 to build in-house silicon photonics technology.

SILICON PHOTONICS

- Silicon photonics leverages benefits of silicon chip ecosystem:
  - Shared design methodologies
  - Outsourced wafer manufacturing to achieve economies-of-scale.

- Juniper's Differentiation:
  - Integration of all photonic elements of an optical transceiver— lasers, detectors etc. — within a single silicon photonics die.
  - Integrating Indium phosphide materials into a silicon process flow right on the silicon wafer gives us the ability to amplify or generate light on chip.
  - The ability to incorporate all optical components within a single, common silicon die fundamentally changes and simplifies how an optical transceiver can be assembled and tested, dramatically reducing costs.

“OPTO-ASIC”



Juniper Networks’ silicon photonics enabled “Opto-ASIC,” a fully integrated transceiver package (left), surface mounted to module board (center left), board assembly placed within module housing with fiber attached (center right), and final QSFP module assembly (right).

“OPTO-ASIC” FUTURES

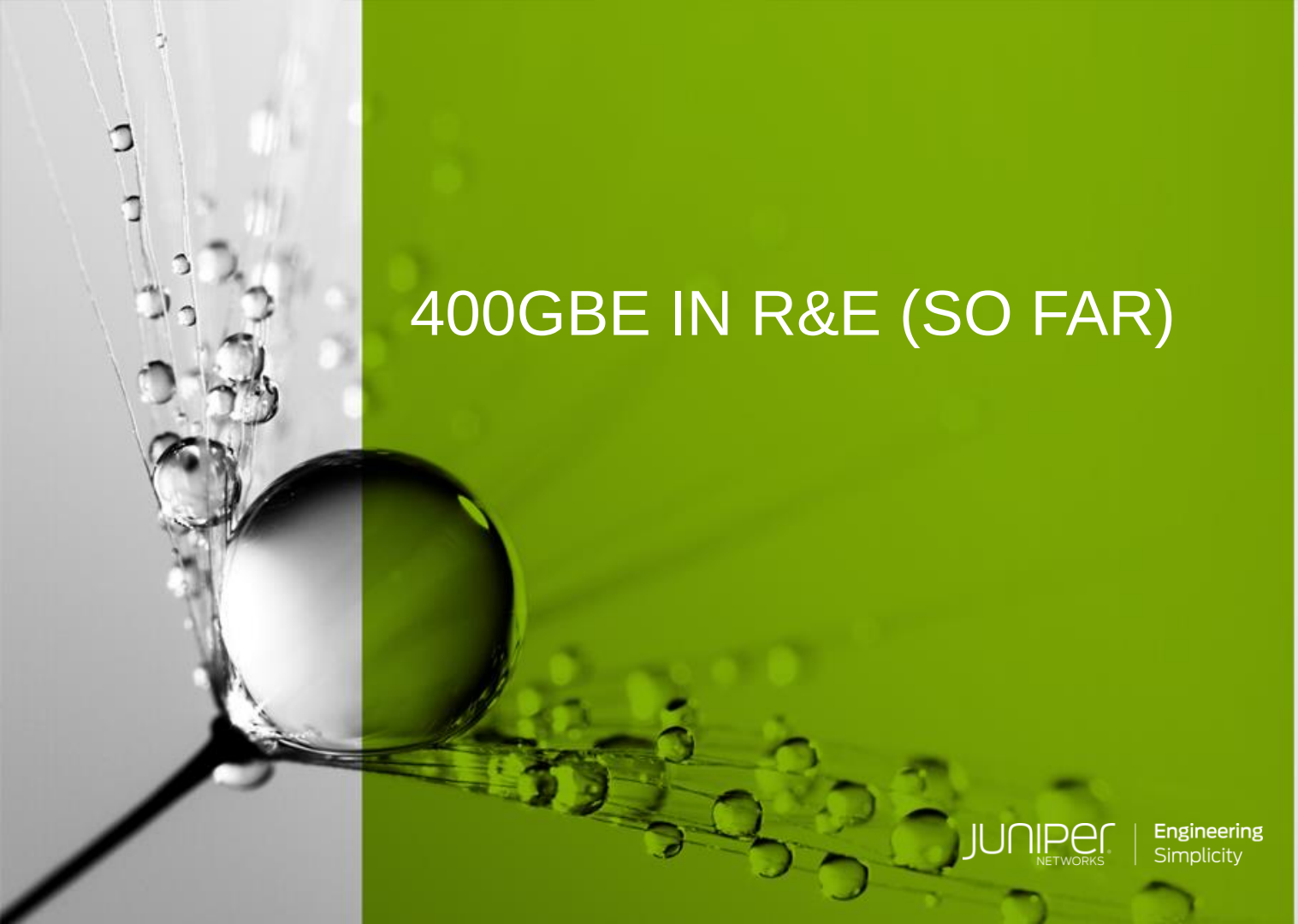
- Juniper’s fully integrated “Opto-ASIC” transceiver
  - densely packages electronic and photonic die in a single, low-cost package
  - completely agnostic to being packaged in existing module form factors (QSFP, QSFP-DD, OSFP, COBO, etc.)

- Network processors (PFEs: Packet Forwarding Engines)
  - Packet Processing capabilities keep increasing exponentially
  - But, are limited by ability to push that much bandwidth in and out of them electrically – Shannon’s Law*
  - Throughput Increase – Possible by integrating photonics & network processor on one Package

- Juniper’s Silicon Photonics technology offers immense potential:-
  - **Integration into the PFE**, along with Penta Silicon and Triton Silicon, improves scaling performance at the line card and system level, to enable petabit-per-sec total system capacity
  - Combining silicon photonics technology with network processors increases system level capacity and performance while decreasing power consumption

*** Shannon's law**: defines the theoretical maximum rate at which error-free digits can be transmitted over a bandwidth-limited channel in the presence of

400GBE IN R&E (SO FAR)



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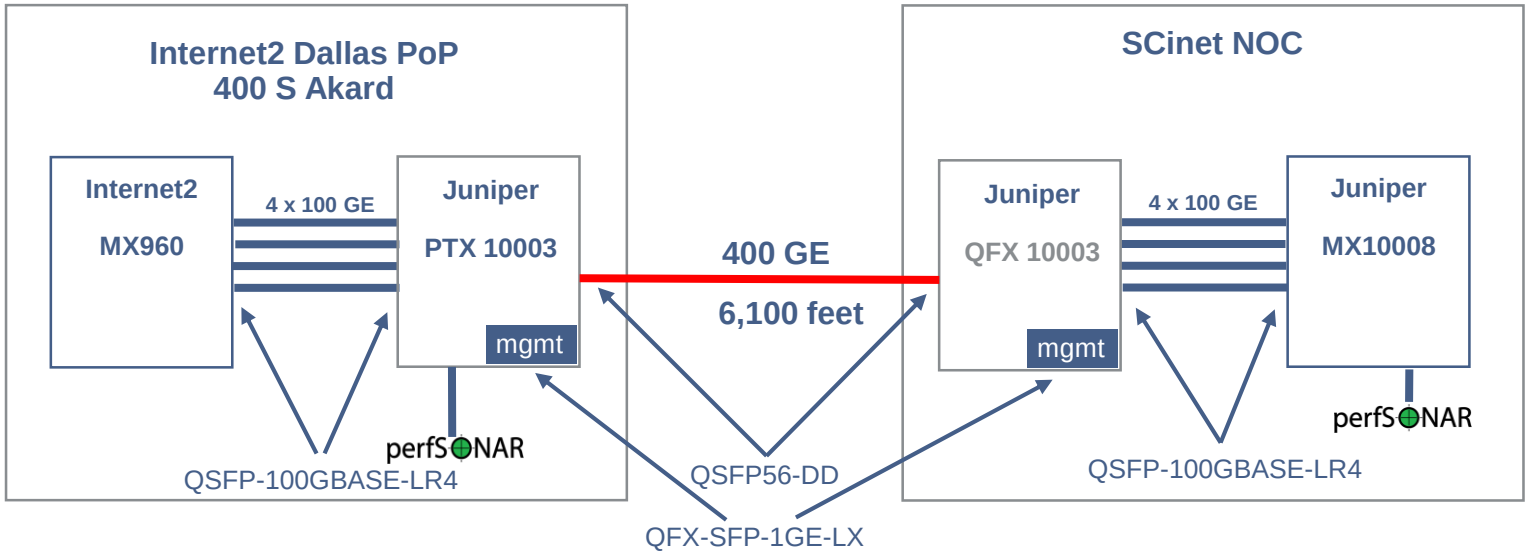
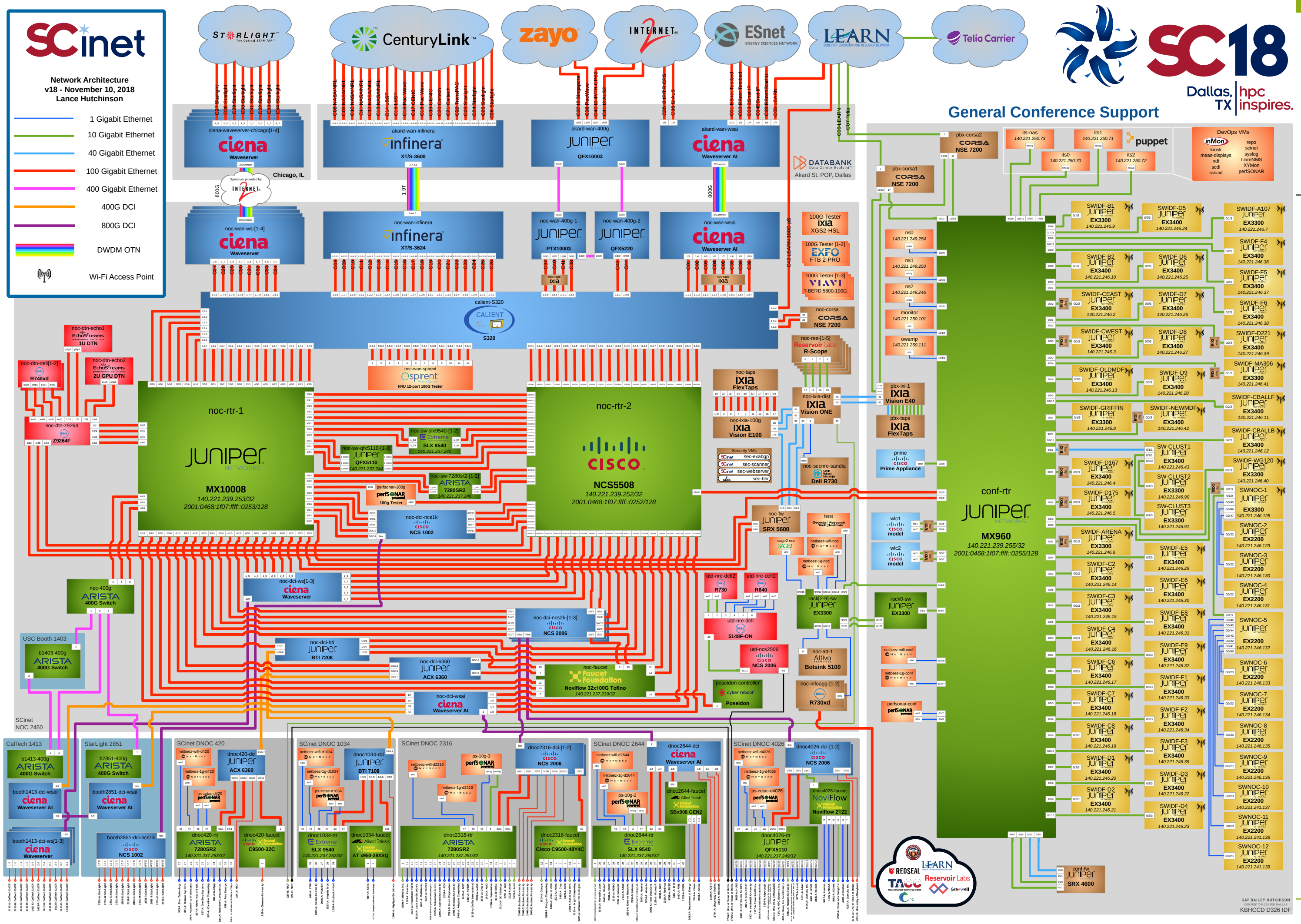
JUNIPER 400 GE @ SC18





400 GE UPTAKE IN R&E NETWORKS IN 2019

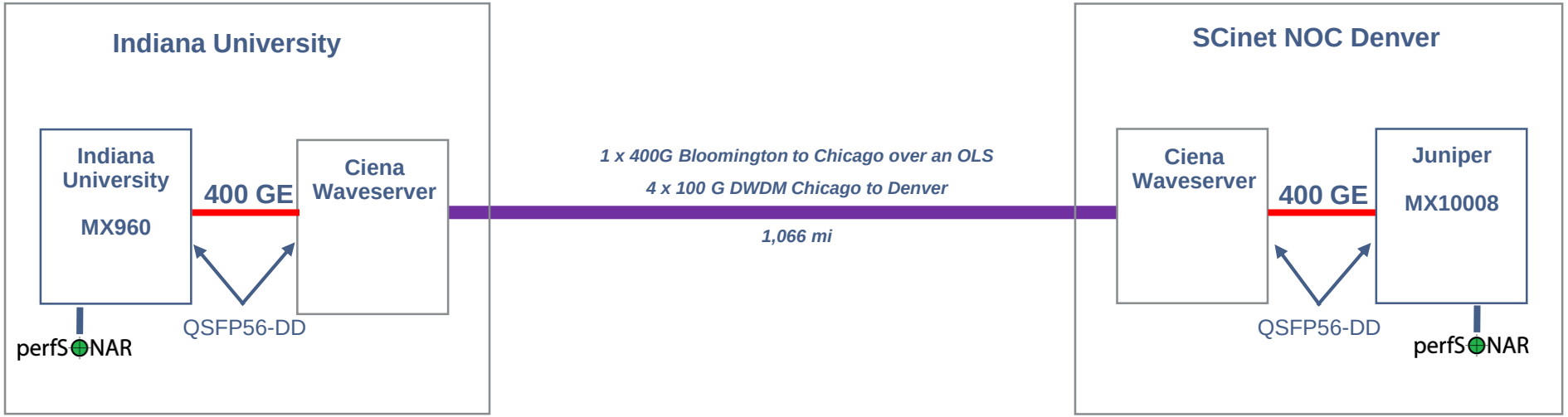
Juniper Account Teams and PLM have had conversations about 400 GE 2019 deployments with:

- A major Supercomputer Center
- Research universities planning on upgrading their WAN access
- Research universities planning 400 GE Science DMZs

We also have had early 400 GE planning conversations with several R&E Network providers

400 GE is coming to R&E Networks this year!

PLANS FOR 2 X 400 GE @ SC19*




THANK YOU /
QUESTIONS?

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