

400G Data Center Switching Deep Dive

Conference Call Details

Friday, January 17 @ 11.30am ET / 8.30 am PT

Dial-in Info:

Please contact your JP Morgan sales representative for details

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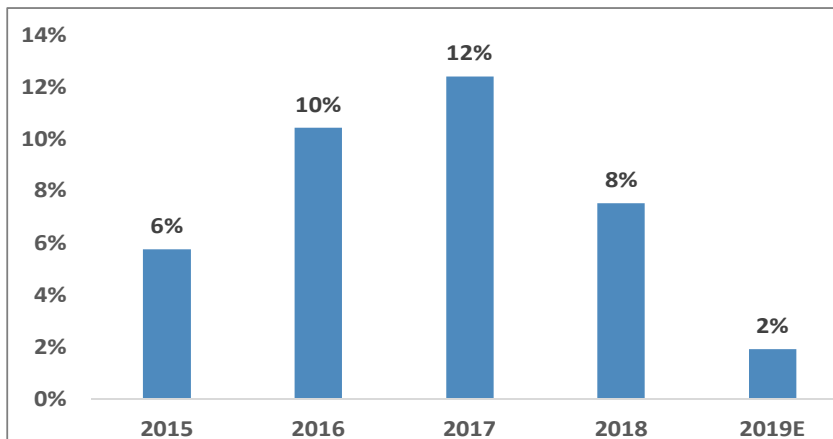
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Industry Landscape

100G Still Core to Near-Term Industry growth

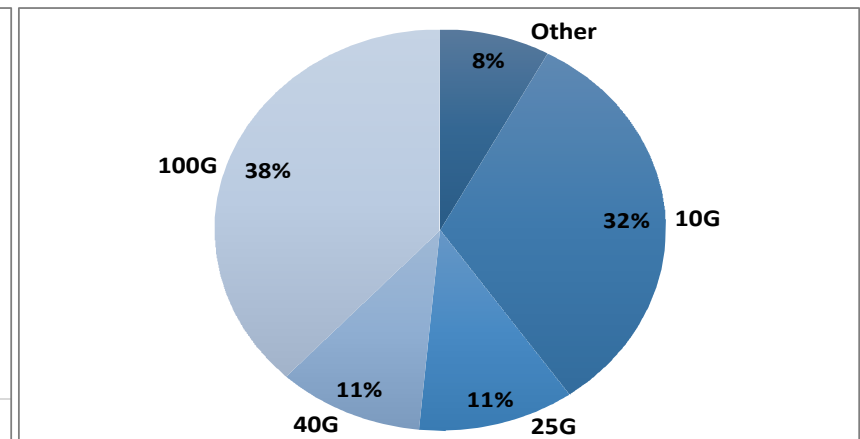
- The DC Switching market (~\$12.6 bn in 2019), has grown at roughly +8% CAGR over the recent years, led by double-digit growth in the cloud Datacenters
- 100G remains the most widely adopted port speed by revenue accounting for 38% market share
- Expect industry growth to accelerate in 2020 from +2% in 2019, led by reacceleration of capex growth from cloud companies to a double digit pace and ramp in 400G refresh cycle

DC Switching Industry Growth



Source: Dell'Oro.

DC Switching Market Share by Port Speed

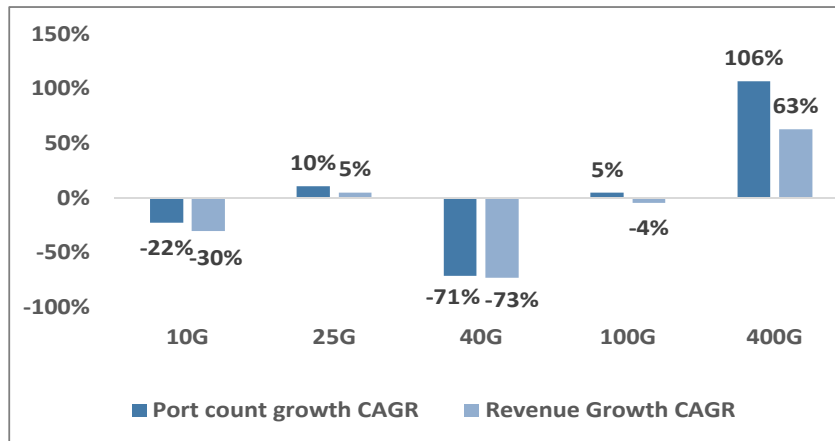


Source: Dell'Oro.

Medium-Term Industry Growth Weighted to 400G

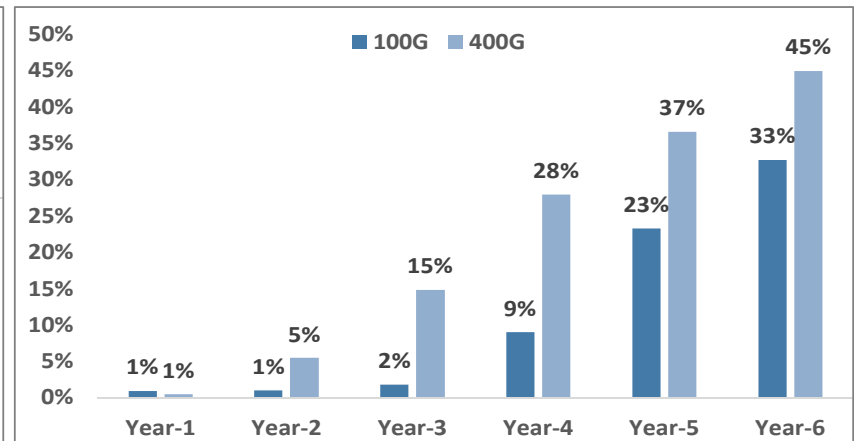
- Medium-term growth for the DC switching market to track in the mid-single digit range, led by strong growth for 400G and continued mid-single digit growth for 100G
- Despite current challenges, expect 400G DC switch adoption to track faster than 100G, by accounting for ~45% of the market in the sixth year after launch relative to ~33% for 100G
 - *Slower adoption of 100G was led by significant delays due to improper form factor (QSFP vs. CFP2), optics and silicon availability*

Port Count and Revenue Growth CAGR (FY19E-23E)



Source: Dell'Oro.

100G vs. 400G DC Switch revenue



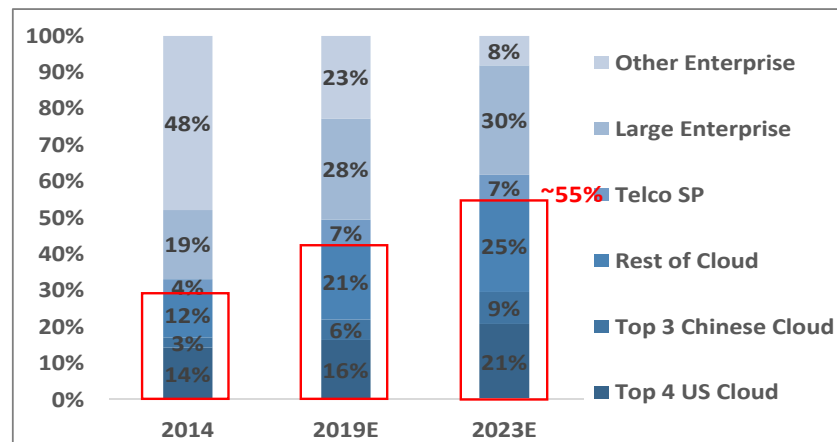
Source: Dell'Oro.

Sizeable Market Opportunity for Switching Vendors in 400G

➤ Expect cloud customers to be the first adopters of 400G and to leverage the latest generation of switching products across their DC, leading to a ~\$10 bn opportunity medium-term

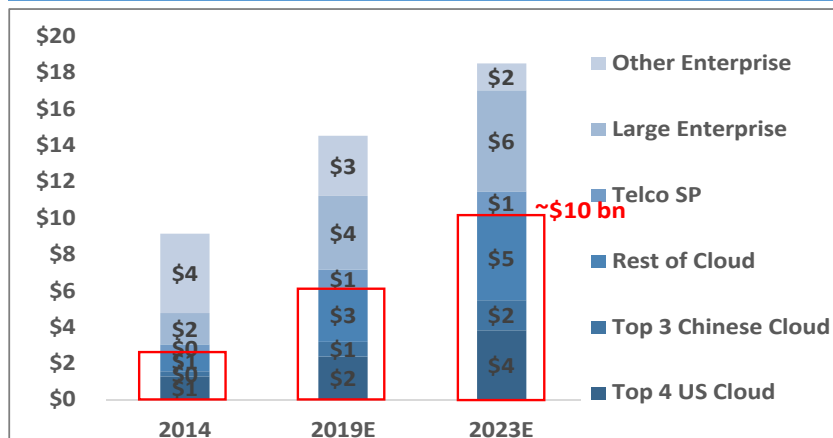
➤ However, immediate opportunity closer to ~\$ 4 bn, on: 1) slower adoption of 400G by Tier 2 cloud providers; and 2) lower likelihood of use of US networking equipment companies by Chinese cloud providers

DC Switching Market



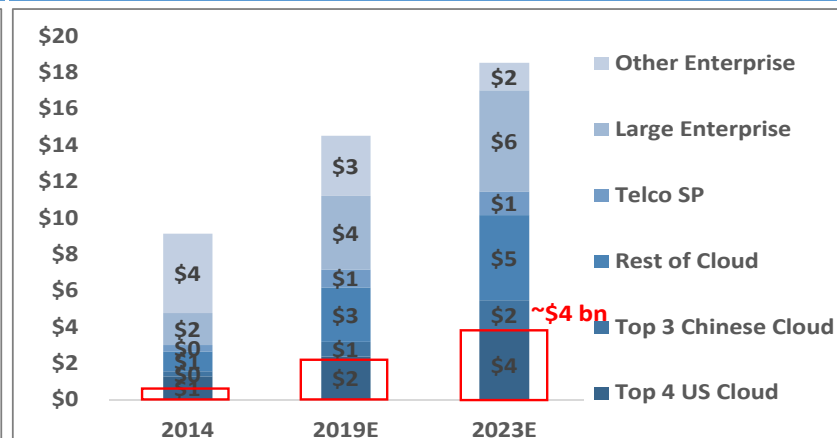
Source: Dell'Oro.

DC Switching Market Opportunity



Source: Dell'Oro.

Near-term DC Switching Market Opportunity



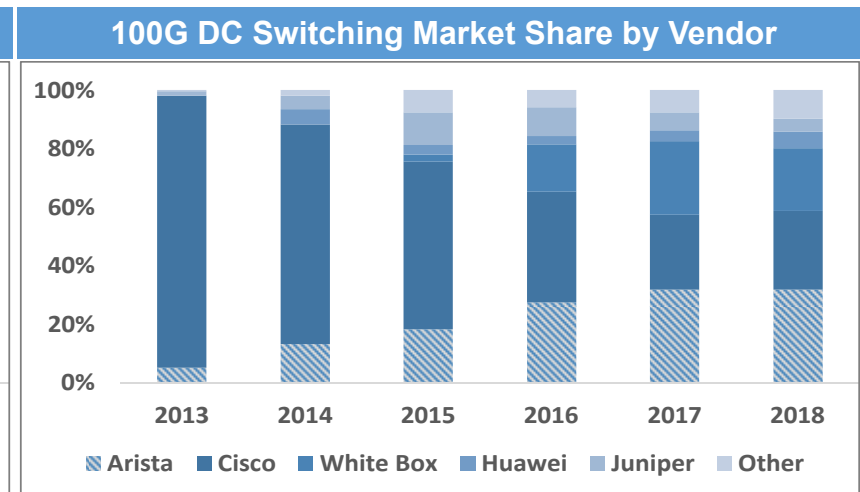
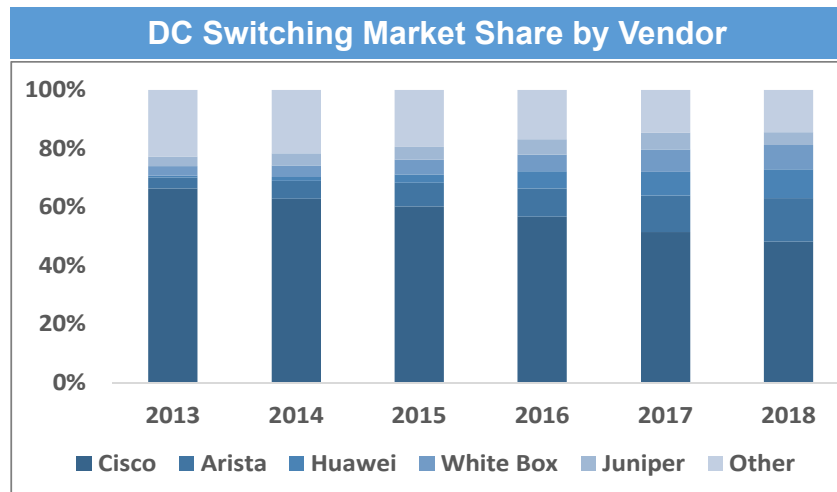
Source: Dell'Oro.

Vendor Landscape in 100G

Arista Was the Clear Winner With Cloud in 100G

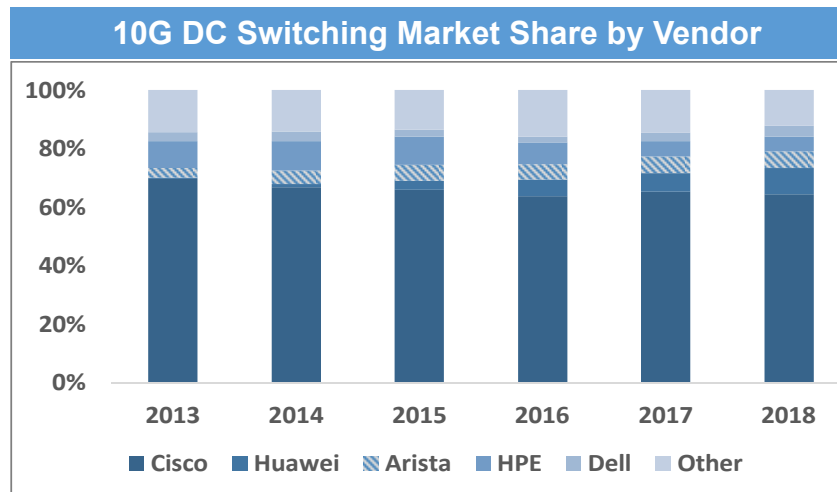
➤ Arista's success in 100G was driven by:

- Entering the market in early stages of adoption;
- EOS operating system, that addressed right feature sets that Cloud customers required;
- Leveraging Broadcom's Jericho chip, which provided the level of de-buffering capabilities that Cloud customers were demanding, particularly Microsoft;
- Capability to roll patches quickly by implementing directly on the Broadcom chip rather than implementing through the SDK;
- Mis-execution from Cisco and Juniper - heavy and over engineered software, and reluctance to offer a merchant silicon based option on part of Juniper

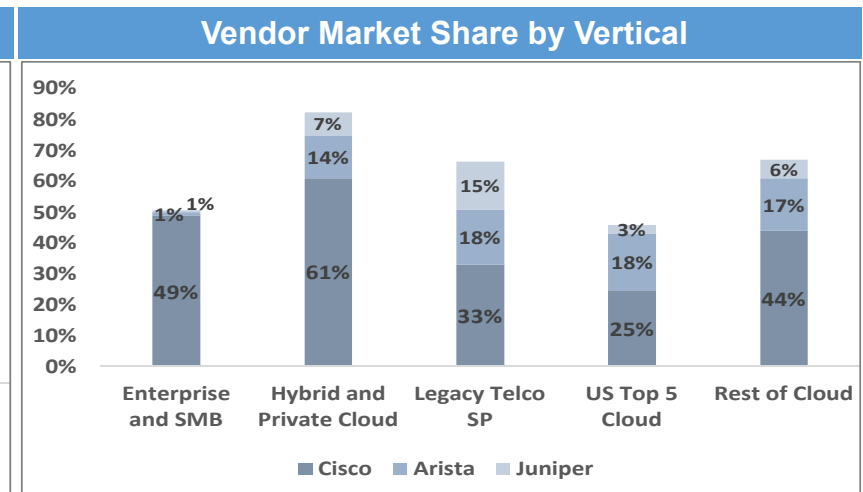


Arista's Share Remains Limited in Other Port Speeds

- Arista's market share in other switching generations has remained stable and limited
 - In the 10G DC switching market, share has remained at low- to mid-single digits over the past five years
 - Cisco continued to maintain strong market share with Enterprises and non-Tier 1 cloud companies – which continued to leverage lower port speeds



Source: Dell'Oro.



Source: 650 Group.

Technology Adoption Roadmap for Cloud Customers

Cloud Companies on Independent Technology Roadmaps

- Transition to 100G switching was driven by large scale adoption of the product across most cloud companies, including hyperscalers, Chinese cloud companies, and US tier 2, most of which moved directly from 25G to 100G products
- Google and Amazon likely to lead 400G adoption within the Top 4 US Cloud companies
- Expect Microsoft to follow only in 2021 and adoption at Facebook to lag significantly given their preference for 200G products before moving to 400G

Switching Port speed in 2019 by Cloud Customer

Top 4 US Cloud Customers			
Google 100G	Amazon 100G	Microsoft 100G	Facebook 100G
Top 3 Chinese Cloud Customers			
Alibaba 100G	Baidu 100G	Tencent 100G	
Sampling of Tier 2 Cloud Customers			
Apple 100G	Oracle 40G		

Source: 650 Group.

Speed Migration at Top 4 US Cloud Customers

	2019	2020/2021	2022/2023	Optics
Google	400G (limited production)	400G	800G	QSFP
Amazon	400G (trials only)	400G	400G	QSFP-DD
Microsoft	100G	400G	400G	QSFP / QSFP-DD
Facebook	100G	200G	400G	QSFP-DD

Source: J.P. Morgan estimates.

Vendor Positioning in 400G

Cisco & Juniper Focused on Silicon Diversity for Differentiation

- **Arista:** Pursuing differentiation in 400G through software and Broadcom's capabilities; targeting DCI and WAN and footprint for incremental share gains
 - *Expect Arista's key differentiation to be relative to EOS, through adding more functionality in the offering, which in combination with Jericho, will better position Arista to displace routers in the DCI and WAN*
- **Cisco:** Leveraging Innovium and in-house silicon to provide silicon diversity
 - *Announced two configurations: Nexus 3408-S offering 32x400G QSFP-DD in 4-RU, and Nexus 3432D-S offering 32x400G QSFP-DD in 1-RU, both leveraging Innovium's Teralynx*
 - *The late 2019 launch of the Silicon One platform is expected to allow the company to provide customers an alternative to Broadcom's Jericho*
- **Juniper:** Earliest to announce the 400G switch, will leverage both merchant and custom silicon
 - *Juniper is aiming to support both Broadcom and own silicon (Q5/Triton), which are both expected to be alternatives for Broadcom's Jericho chip*
 - *Updated switching OS ("Junos OS Evolved"); more geared towards cloud applications, addressing the challenges faced with the heavy footprint of the prior switch OS*
 - *Planning to offer intra-data center optics, to offer a lower cost product to cloud customers, by packaging the switch hardware and the optics*

Current Vendor Landscape at Hyperscalers

- The ToR and Leaf layers in the DC being less complex have seen higher use of white box solutions and use of Cisco and Dell products
- The more complex layers of Spine and DCI have seen the use of Arista leveraging Jericho chip for its larger routing tables and greater L3 capabilities
- Existing share in 100G limits incremental share opportunities for Arista in 400G transition
- Higher opportunity for share gains for Cisco and Juniper within the Spine and Leaf layers, and will need them to displace Arista

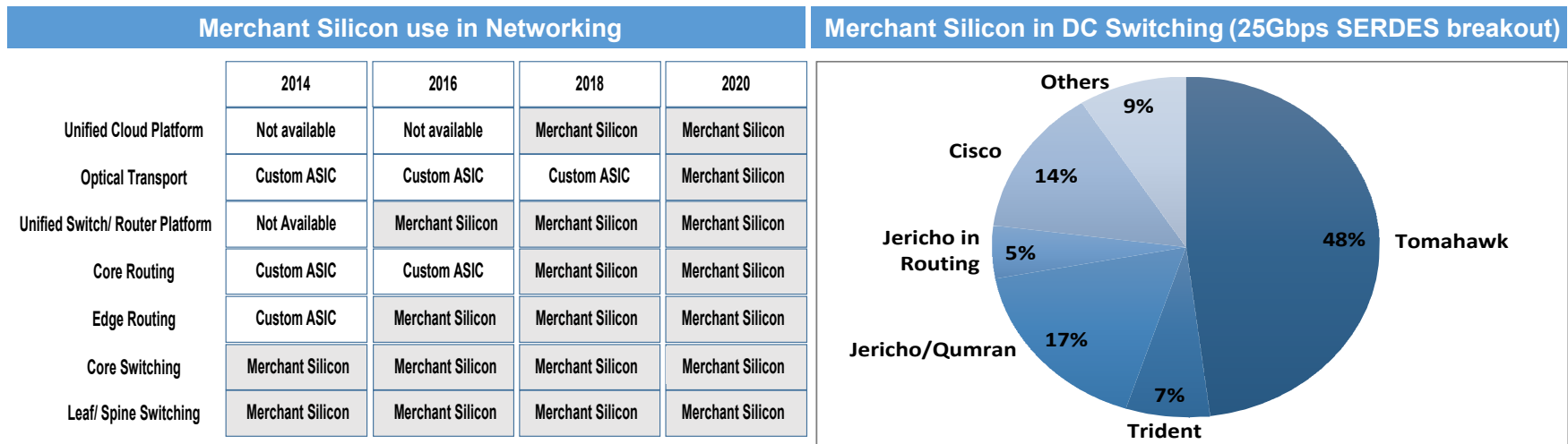
Current Vendor Landscape at Hyperscalers				
	ToR	Leaf	Spine	DCI
Google	X	X	X	X/Juniper/ Cisco
Amazon	X	X	X	Juniper
Microsoft	Arista/Cisco/ Dell	Arista/Cisco/ Dell	Arista	Arista
Facebook	X/Arista	Arista/ Edgecore	Arista/ Edgecore	Arista/Juniper /X
Baidu	X/H3C	Huawei/H3C	Huawei/H3C	Huawei/H3C
Alibaba	Cisco/H3C/ Ruijie/Huawei/ i/X	Cisco/H3C/ Ruijie/Huawei/ X	Cisco/H3C/ Ruijie/Huawei/ /X	Huawei/H3C
Tencent	Cisco/H3C/ Ruijie/Huawei/ i/X	Cisco/H3C/ Ruijie/Huawei	Huawei/H3C	Huawei/H3C
Apple	Arista/Cisco/ X	Arista/Cisco	Arista	Cisco/Juniper

Source: 650 Group.

Merchant Silicon vs. Custom Silicon

Focus on Silicon diversity in 400G

- Hyperscaler priority in 100G was to reduce lock in to certain vendors that were quite reliant on their in-house silicon development
 - *Arista's success in leveraging Broadcom's merchant silicon solutions gave them a leadership position*
 - *Increasing capability of merchant silicon solutions up the networking stack aided adoption at hyperscalers*
- The dominant position for Broadcom in DC switching with Tomahawk, Trident, and Jericho chips is now driving hyperscalers to look for silicon diversity in 400G
 - *Cisco's Silicon One platform, Juniper's Q5/ Triton, Innovium, and Barefoot all likely to be seen as alternatives*
- However, few competitors have the R&D scale/IP/execution to match the cadence/capabilities of Broadcom's networking silicon franchise, thus creating a high barrier to entry



Source: 650 Group.

Source: J.P. Morgan estimates.

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Challenges and Beneficiaries

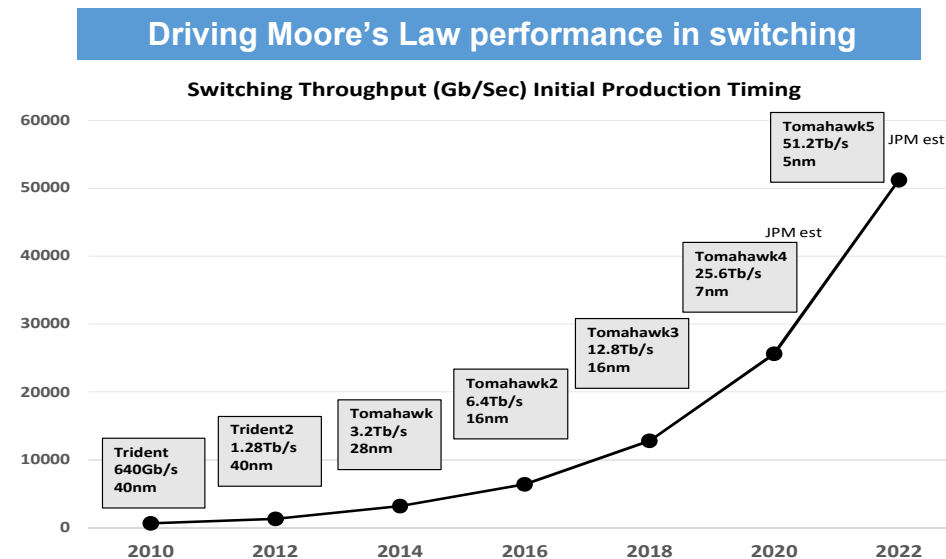
Production Delays in Optics Leading to Delay in 400G Adoption

- Delay in high-volume availability of ZR optics has delayed the adoption of 400G switching products
 - *Use of 400G compact modular optical transport products (supplied by Ciena and Infinera) for DCI lowers the value proposition for hyperscalers; customers can drive costs lower by adoption of pluggables*
- Challenges with 400G optics have related to commercialization and high volume manufacturing
 - *Both inter-data center optics (10km to 80km), in the form of 400G ZR/ZR+, and intra-data center optics (<10km), in the form of 400G QSFP-DD, have had significant delays due to yield issues*
 - *Low shipments till now, well-below the necessary output for cloud customers to leverage these products extensively*
 - *Expect both inter- and intra-data center optics to be available in volume between mid-2020 and early 2021, following delays of roughly one year*
- Expect vendors like Inphi and Acacia to gain from ZR adoption, see tailwinds for optics module manufacturers
 - *Expect IIVI to benefit given Finisar's position as one the leading datacom module provider*

Impact on Semiconductor from 400G

Broadcom (OW): Leader in cloud switching/ routing silicon market-driving 2x performance gains every 2 years

- Believe Broadcom owns 80-85% of the cloud/hyperscale networking switch silicon market (and gaining strong share in the routing market) with flagship Tomahawk chipset family
 - Tomahawk 3 chipset platform (PAM4 50G/port supporting 200G and 400G optical connectivity) started ramping in 2H18 with Google (200Gbps) and at Amazon in 2H19 (400Gbps), driving the strong double-digits Y/Y growth in DC silicon franchise in 2019.....Looking to drive its Tomahawk 3 chipsets into upgrade cycles from Microsoft, Facebook, Alibaba, Baidu, and Tencent in 2020/2021
 - Maintaining 2-step lead over competitors as it is already sampling its next gen Tomahawk 4 (7nm) chipset and is deep in the design phase of its Tomahawk 5 (5nm) chipset , driving confidence of company retaining 80-85% market share of the \$3B market in cloud/hyperscalerecently taped out next-gen Jericho 2+ 7nm
 - Next step in networking silicon evolution? We believe Broadcom has recently won a networking switching ASIC opportunity at a Tier-1 US cloud/hyperscaler for next generation 100Gb/s per port data speeds.



Source: Broadcom, J.P. Morgan Research.

Inphi (OW) market leadership in 200G/400G optical connectivity/Digital Signal Processing

- Leadership in optical connectivity with its PAM4 digital signal processor (DSP) silicon platform (including driver and amplifier), enabling it to capture 80%+ share of the 200G/400G optical module wins targeted for cloud/hyperscalers
 - *In addition to benefitting from the initial 200G ramp at Google, we believe Inphi started shipping production silicon to support Amazon's 400G switch port build-out starting in 4Q19*
 - *Believe company has captured a majority of the 200G and 400G module sockets that will ramp with the other US cloud titans such as Microsoft and Facebook in 2020/2021*
 - *Believe Inphi has strong design win traction in China, which starts to ramp its 400G networking upgrade cycle in 2020*
 - *Believe the PAM4 DSP chipset used in the Alibaba 400G module is Inphi's Porrima 2nd or 3rd generation chipset platform*
 - *Company set to generate >\$90M in PAM4-related chipset revenues in 2019 and >\$160M in 2020*
 - *200G/400G for switching/routing platforms (white box and OEM)*
 - *200/400G for Artificial Intelligence/Deep learning clusters (cloud/hyperscale)*
 - *200G/400G for high performance compute clusters*
 - *200/400G for 5G mid and backhaul*
 - *First to sample full solution 400G ZR (DSP, Silicon photonics front-end, driver, amplifier) at 7nm.*

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Companies Discussed in This Report (all prices in this report as of market close on 16 January 2020)

Broadcom Inc (AVGO/\$307.05/Overweight), Inphi (IPHI/\$81.89/Overweight)

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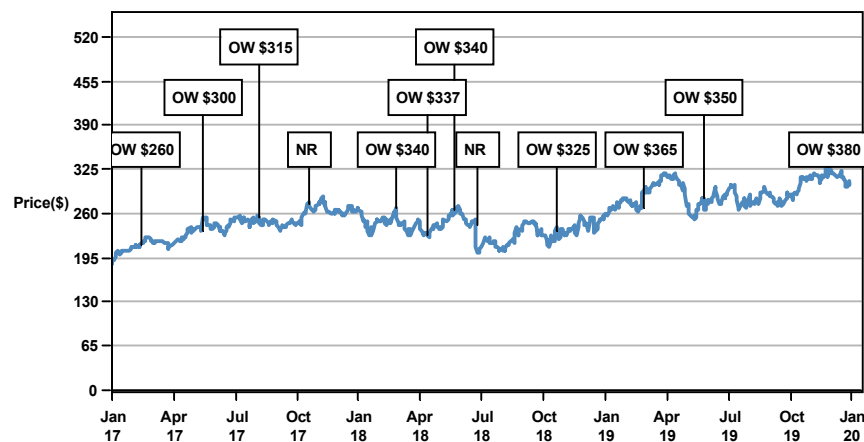
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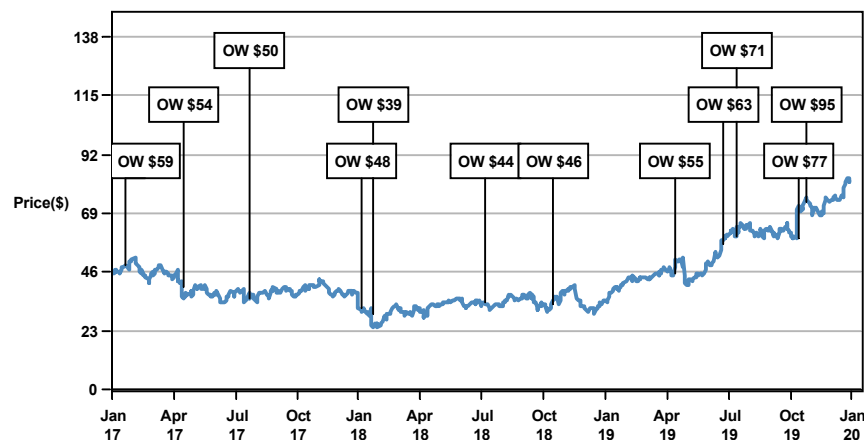
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Broadcom Inc (AVGO, AVGO US) Price Chart



Source: Bloomberg and J.P. Morgan; price data adjusted for stock splits and dividends.
Initiated coverage Nov 01, 2010. All share prices are as of market close on the previous business day.

Inphi (IPHI, IPHI US) Price Chart



Source: Bloomberg and J.P. Morgan; price data adjusted for stock splits and dividends.
Initiated coverage Aug 30, 2016. All share prices are as of market close on the previous business day.

Date	Rating	Price (\$)	Price Target (\$)
02-Mar-17	OW	215.14	260
02-Jun-17	OW	234.59	300
25-Aug-17	OW	255.05	315
06-Nov-17	NR	273.63	--
16-Mar-18	OW	267.76	340
01-May-18	OW	229.42	337
08-Jun-18	OW	264.68	340
12-Jul-18	NR	243.44	--
08-Nov-18	OW	234.40	325
15-Mar-19	OW	268.20	365
14-Jun-19	OW	281.61	350
13-Dec-19	OW	327.80	380

Date	Rating	Price (\$)	Price Target (\$)
08-Feb-17	OW	48.92	59
03-May-17	OW	40.54	54
08-Aug-17	OW	35.43	50
22-Jan-18	OW	32.07	48
08-Feb-18	OW	29.71	39
25-Jul-18	OW	34.23	44
02-Nov-18	OW	33.72	46
01-May-19	OW	45.66	55
11-Jul-19	OW	57.04	63
02-Aug-19	OW	60.24	71
30-Oct-19	OW	59.44	77
12-Nov-19	OW	73.73	95

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