Bloomberg Intelligence

Cloud Models Evolving, Fragmenting With Workloads,Tech

BI Computer Hardware & Storage, Global Dashboard

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1. New Topologies, Custom Gear Meet Cloud 2.0's Varied Workloads

(Bloomberg Intelligence) -- Cloud services in the public, commercial and hybrid domains are rapidly expanding and diversifying. These large, varied workloads are driving growth among multiple types of cloud systems and architectures. Server processors are morphing,

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based on workloads, as are types and tiering of storage. Network gear is commoditizing more slowly, having started with the edge. System topologies are evolving and flattening, with more system intelligence and control migrating from hardware to software and into an app's code.

Cloud disruption aids sales for vendors such as NetApp, Quanta, Nvidia and Cavium. With Intel and AMD, these vendors are more relevant in the cloud model than HP-E, IBM and EMC. Workloads and IT spending are moving to Amazon or Microsoft clouds or optimized in-house on Pure Storage or Nutanix systems. (10/17/17)

Topics

Systems Match Workloads

Customized Workload-Matched Systems Are Default in Cloud 2.0

Customized server shipments may yet rise as these are carefully matched to specific workloads in public clouds of Microsoft, Amazon.com and Google for maximum efficiency or lower costs. Options in storage, processor chips and architectures are driving the next evolution in cloud infrastructure. (10/12/17)

2. Servers Matched to Workloads at Scale a Key Feature of Clouds

Amazon.com and Microsoft clouds have shown how workloads matched to appropriate servers can improve performance and reduce cost through scale. The focus on server costs has increased as storage expenses declined and networking technologies became more standardized. Public-cloud workloads on a large scale make systems cheaper, yet specialized CPUs and software make some public-cloud IT more powerful than corporate clouds, which have been driven by security fears and compliance requirements.

Cloud architectures in servers have evolved to match workloads. Artificial intelligence needs pair GPUs with servers, while web work is jointed to lower-end machines. Volatile data goes with solid-state storage and archiving ties in with low-cost, high-capacity storage. Hybrid clouds aim for a balance. (10/12/17)

2017 Public Cloud IT Services Revenue ($ Million)

Source: IDC
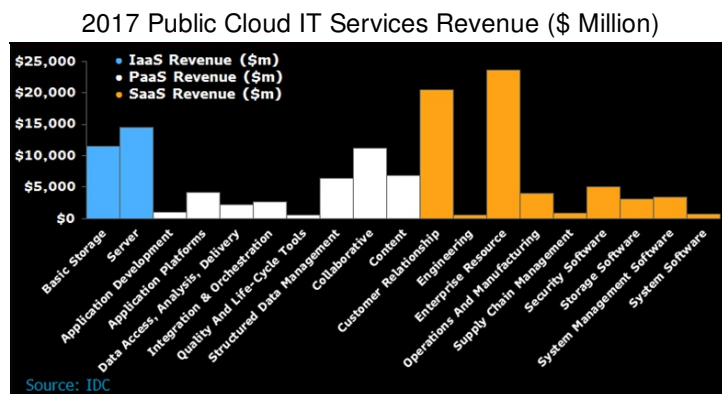
3. Amazon and Azure Widen, Deepen Computing Choices in Public Cloud

Servers are the most disaggregated, advanced and commoditized piece of cloud infrastructure. Amazon Web Services offers about 45 computing node options in its EC2 Service, while its lower-end LightSail, which rents for as little as $5 a month, offers virtual servers with fixed amounts of RAM, storage, core processing and data transfer. Other options include task-specific rental computing. Public clouds' embrace of non-Intel CPUs also widens choices for sub-scale computing-resource buyers such as small businesses.

Client familiarity with Microsoft's product platform and similarity to internal IT systems at public cloud scale may be the strongest value proposition to Azure's public and hybrid platforms. (10/12/17)

AWS and Microsoft Azure Compute Products

Source: Microsoft, Amazon

4. IT Spending Cuts Led by Smaller Companies, Noncore Systems

Corporate IT's move to the cloud compresses information tech spending. The declines may be faster in small and medium businesses, rather than larger corporations. Many legacy IT vendors, such as Dell/EMC and HPE, point to long-tailed IT spending but only some of that -- from large Fortune 500 names on core IT gear -- may be stable while other companies cut spending more aggressively. Public-cloud IT is more efficient, has higher scale and uses nonbranded-gear, all of which pressures sales for IT gear makers. (10/12/17)

Small and Medium Business IT Spending

Source: IDC
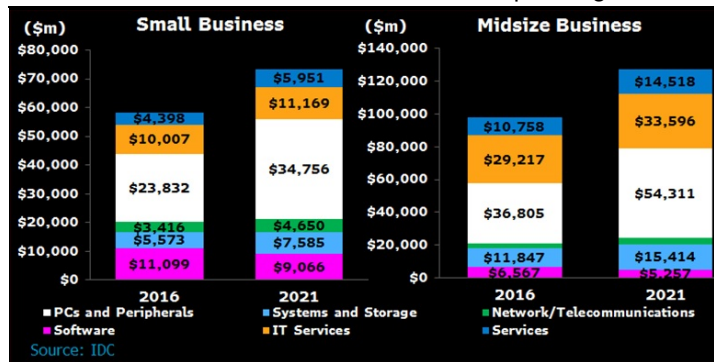
5. Custom Chips, Storage Options Propel Specialized Cloud Systems

Multiple choices in computing, networking and storage components that offer varied performance, power, capacity and cost traits are driving diverse system uses in the data center. Intel's CPUs now compete with AMD, Qualcomm and Cavium, while its graphics processors battle Nvidia and AMD. Hard-drive storage makers such as Seagate are losing share to solid-state drives (SSDs) from Samsung and Micron/Intel. Networking gear is also getting commoditized amid the rise of Microsoft's SONiC switch operating system.

SSDs offer higher performance and lower power use at higher cost vs. HDDs. Intel x86 processors are a general purpose CPU, but graphics processors offer higher performance for AI-training. Intel's Altera chip integration makes it suitable for specific workloads. Nonbranded networking gear cuts costs. (10/12/17)

Latest High End Nvidia, AMD GPUs & Intel CPU Specs

GPU Specifications	AMD Radeon RX Vega	Nvidia GeForce GTX 1080 Ti
GPU Architecture	AMD Vega 10	Pascal
Stream Processors	4,096	3,584
Texture Units	256	224
Render Output Units	64	88
Memory Capacity	8GB HBM2	11GB GDDR5X
Memory Bus	2048-bit	352-bit
Performance	12.5 TFLOPs	11.8 TFLOPs
Launch	2Q17	1Q17
CPU Specifications	AMD Ryzen 7 1800x	Intel Core i7-6950X Extreme
# of CPU Cores	8	10
# of Threads	16	20
Base Clock Speed	3.6 GHz	3.00 GHz
Cache	16 MB	25 MB
Max Turbo Frequency	4 GHz	4 GHz
Memory	DDR4	DDR4
Launch	1Q17	2Q16

Source: Company Websites, PCGamesn.com

Storage Unraveled, Flattened, Optimized in Cloud 2.0

Storage Simplified, Flattened, Software-Driven in Cloud Shift

Storage architectures are being flattened and simplified in evolving cloud models. Storage intelligence is now heavily driven by software, but appliances can exist on-premise and in private or public clouds. NetApp appears to have evolved more than EMC and HPE in this IT shift. (10/16/17)

6. Not All Storage Systems, Vendors Benefit From High Data Growth

The amount of stored data continues to expand by about 42% a year, growth that trickles down unequally across storage architectures, gear makers and component suppliers. While rising data is expanding storage systems at cloud service providers such as Amazon.com, Google and companies such as HP-E and EMC, most of it is in

unstructured data. The features needed to store such data vary widely, leading to different consumption patterns between public, private and hybrid clouds and other companies.

Data access, latency, security, location, regulations and costs are used in crafting storage systems and choosing vendors. Proprietary systems from Dell/EMC, NetApp and HP-E, and self-designed systems made by Quanta, offer polarizing choices. All-flash arrays and converged systems are growing rapidly. (10/16/17)

Consumer Cloud Storage Growth

Source: Cisco
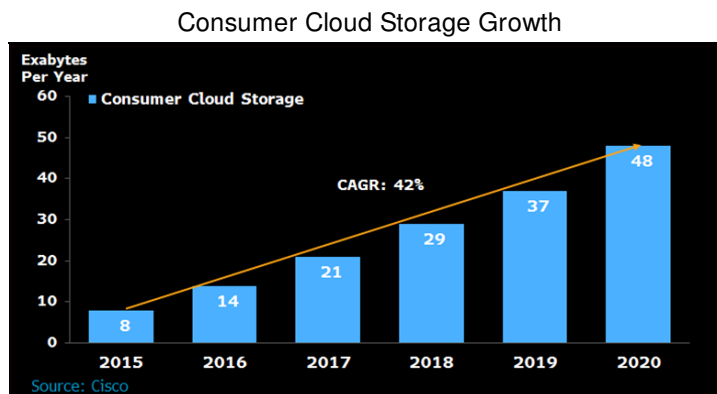
7. Workload, Not Vendors, Driving Cloud Server and Storage Choices

The type of processing or storage activity by the server, storage or networking system -- known as the workload -- has become the key determinant of the kind of system the cloud or corporate IT departments are choosing. Disaggregated components and systems from companies such as Quanta are inexpensive and widely used in public clouds, while specialized ones from Nimble, Nutanix, Pure Storage, HP-E and NetApp are choices for corporate IT and private and hybrid clouds.

Corporations are slowly moving to systems that can self-aggregate to make a private cloud, such as HP-E or Dell, or connect to a public cloud such as NetApp. Amazon.com and Azure have highly customized storage clusters close to computing units. Both come in multiple flavors, based on workload. (10/16/17)

Corporate Cloud Strategies vs IaaS Storage Revenue


Source: IDC
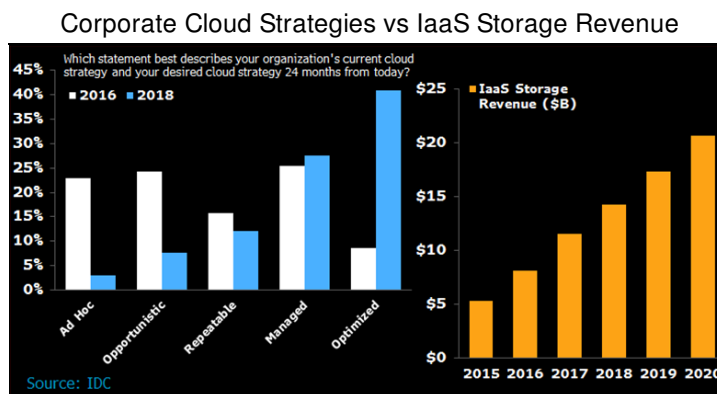
Public Vs. Private Storage

Level of Unraveling Storage Separates Public, Private Clouds

Public clouds typically feature flat, high-capacity, relatively simplistic storage as close as possible to the computing system. Private clouds and non-cloud corporate IT often feature hierarchical storage or separate storage systems with their own intelligence and software. (10/13/17)

8. Unraveled Storage Systems Separate Public, Private Clouds

The move from complex storage-system architectures to simpler models commoditizes system gear and its components and likely accelerates as cloud-volume clout grows. Proprietary gear makers EMC and NetApp systems have expanded software offerings to counter this trend. NetApp's Cloud OnTap software can now be used on commodity systems and connect to Amazon or Microsoft - its recently launched NFS product in Azure only extends its connectivity between private and public clouds.

Public clouds' adoption of a fundamentally different construct, along with their scale, enabled this movement. Private clouds use this approach for newer workloads, while older IT systems are confined to separate storage silos for data storage. (10/13/17)

Public and Private-Cloud Storage Revenue

Source: IDC
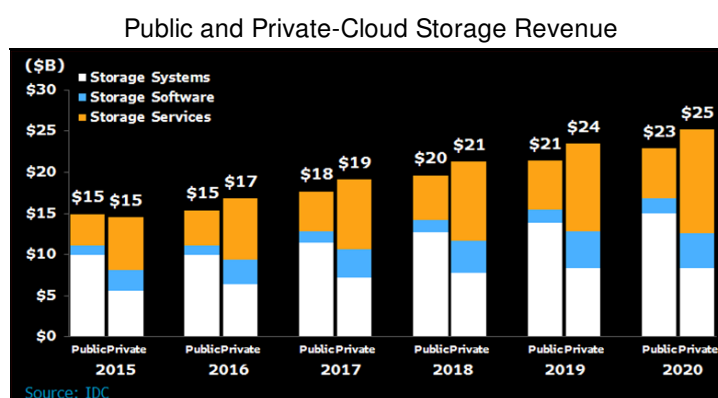
9. Expanding Public Cloud Offsets Large, Stagnant Non-Cloud Storage

Legacy-storage systems' $25 billion sales may decline slowly through 2021, but their size -- 51% of the market -- keeps them relevant. Public clouds are the fastest revenue and petabyte growth prospect, according to IDC. Storage-system infrastructure, excluding software and services, is projected to be a $49 billion market in 2017, growing at a 3% annual rate to $52 billion in 2020. Public-cloud systems may far outpace this growth at 9% and may account for about two-thirds of infrastructure revenue in 2020.

Dell/EMC, NetApp, IBM and HP-E were 63%, or $3.4 billion, of the $5.3 billion in the external-storage systems market in 2Q17. Internally attached storage that uses hard drives from Seagate and Western Digital was $4.7 billion, while other models make up the rest of the $5.7 billion market. (10/13/17)

Enterprise Storage Systems Forecast

	2016	2017	2020	2016-2020 CAGR
External Storage	$24.5	$24.4	$24.3	0%
Internal Storage	$17.9	$18.3	$20.1	3%
Other (Incl. Public Cloud)	$4.8	$5.8	$8.0	14%
Enterprise Storage	$47.3	$48.5	$52.4	3%
Enterprise Storage Systems	$47.3	$48.5	$52.4	3%
Storage Services	$40.1	$42.0	$47.3	4%
Storage Software	$15.8	$16.3	$19.1	5%
Total Enterprise Storage, Software, Services	$103.2	$106.8	$118.8	4%

Source: IDC
Note: Values are shown in $Billions

10. Amazon, Azure Are Leading the Public Cloud Pack for Most Apps

Gartner's scoring of cloud infrastructure shows Amazon Web Services and Microsoft's Azure to be capable for most apps, while standing out in four of the five areas scored. App development, batch computing, cloud-native apps and the Internet of Things were favorable workloads for public-cloud transition. These typically offer lower cost and greater agility, with minimal IT system-management burden. General business applications scored lower, likely due to its in-company integration and security and compliance needs. (10/13/17)

Cloud Capabilities by Use Case

Source: Gartner
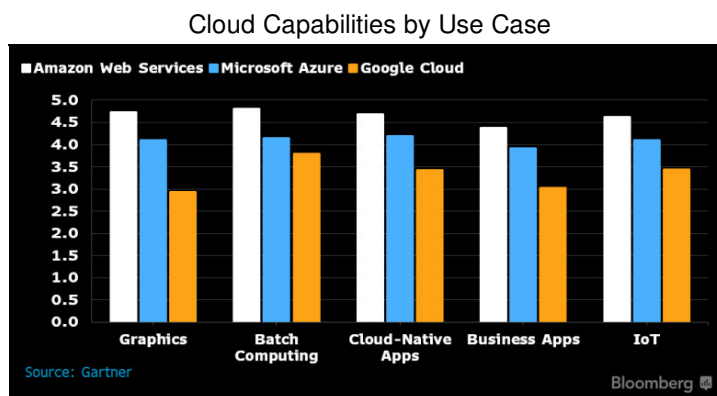
11. Private Clouds Spend on Software Services, Amazon Buys Hardware

Private and public clouds starkly differ in their focus on hardware vs. software and services. Public clouds spend almost two-thirds of their IT budgets on hardware systems (their app platforms have built-in management hardware tools). Private clouds spend the same ratio of IT in services and software that companies such as Google and Facebook do in hardware. Amazon and Microsoft may prefer their HDDs and NAND memory-based SSDs be less smart as data-error checks and deduplication tools are built into their apps.

Private clouds spent 38% of their 2016 storage budgets on hardware, with 18% on software and 44% on services. Private clouds spent $10.4 billion on software and services, almost 2x that of public-cloud spending. (10/13/17)

Private and Public Cloud Spending

Source: IDC
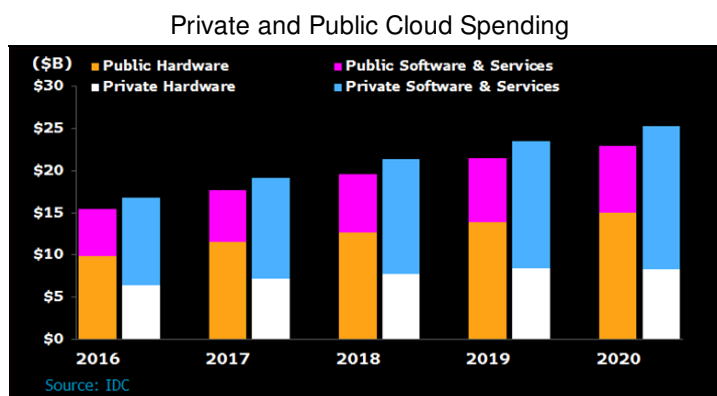
**SSDs Growth In Data Centers**

Solid-State Use Has Substantial Room to Expand in Data Centers

Use of solid-state drives in data centers will likely continue to increase until public clouds, private clouds and corporate IT all stabilize at an optimal mixture of higher-speed SSDs and higher-capacity hard drives. That mix may be roughly 20% of storage in SSDs. Current penetration is well below 10%. (10/16/17)

12. Cloud Providers, Companies Use Solid-State Drives Differently

Both cloud and non-cloud models are expanding their use of solid-state drives. Systems with varied workloads are testing the use case for NAND memory-based SSDs, which cost as much as 6-18x per terabyte of hard-disk storage. Public clouds from Amazon.com, Facebook and Microsoft are more likely to use lower-quality, cheaper NAND or SSDs for their low-latency solutions, while corporations are more likely to embrace all-flash arrays and higher-end SSDs embedded in EMC or NetApp solutions.

Solid-state drives store 8% of the enterprise storage, according to Gartner. This is projected to rise to 15% by 2021, with 52% data growth in this segment. Stored data on HDDs is growing, too, but only at a 29% rate. Western Digital makes HDDs and SSDs. Seagate is heavily skewed toward HDDs. (10/16/17)

Enterprise SSD Revenue ($ Millions)

Source: Gartner
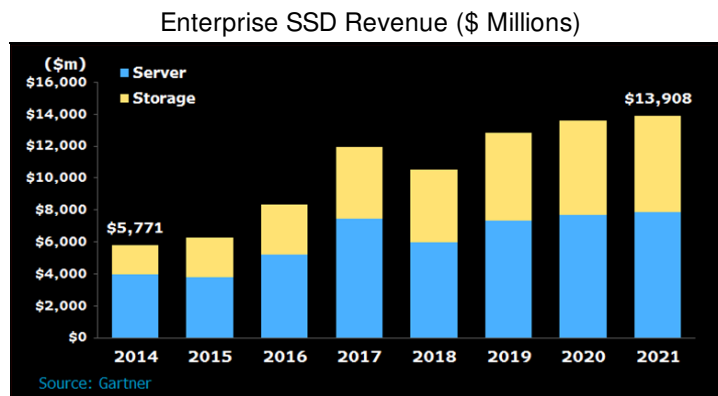
13. Corporate IT's Solid-State Drive Use Is Likely to Grow Markedly

IDC expects that by 2021, 14% of all latency-sensitive, mission-critical storage will be stored on NAND flash memory. Typically 20-25% of an organization's storage is on this medium. The remainder will be on cheaper, higher-capacity hard-disk drives. Even by 2021, high-capacity hard drives may still be the predominant storage medium. Once the tiering between solid-state drives and hard drives is complete, both segments may revert to the long-term rate of data growth.

Seagate and Western Digital's hard-drive businesses aren't structurally challenged, as solid-state drives widen their use in more enterprise, cloud and PC markets. Samsung, Intel, Micron and Toshiba/Western Digital sales have gained from tight supply and demand in NAND, along with increasing prices. (10/16/17)

HDD vs SSD Enterprise Storage

Source: IDC
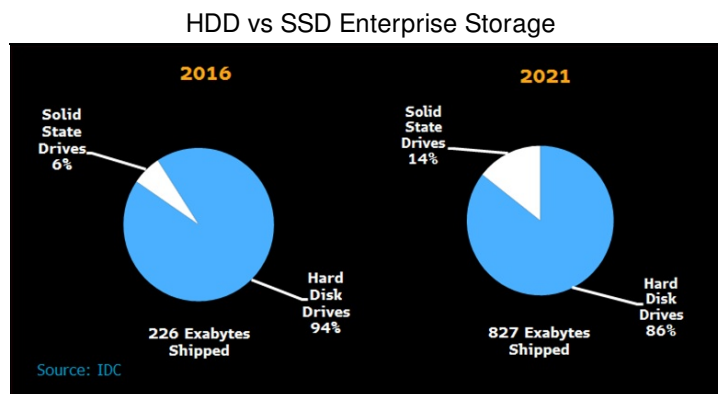
All-Flash Arrays

All-Flash Arrays a Key Technology in Cloud Storage Momentum

Storage vendors such as NetApp are using all-flash array products to gain share. This has made companies such as Pure Storage and Nimble Storage (now part of HPE) popular, as EMC/Dell remains weak. NetApp now has sales momentum with a holistic approach to storage. Its solutions span storage mediums and architectures. (10/13/17)

14. Flash Arrays May Reduce the Cost of Software in Private Clouds

Flash storage systems use NAND memory transistor-based chips rather than spinning hard-disk drives, helping them to keep up with fast, predominantly Intel x86 CPU chips on servers. The resulting CPU chips-to-storage-capacity may be lower in all-flash systems from Nimble and Pure vs. legacy EMC systems. Because software licensing is based on CPU chips and the cores within them, software costs associated with Microsoft Windows, Red Hat Linux and Oracle Database may be lower in enterprise private clouds. (10/13/17)

HDD, SSD Exabytes Shipped & Price Per Gigabyte

|	2016	2017	2020	2016-2020 CAGR
Exabytes Shipped				
HDDs				
Business-Critical	199	294	647	34%
Mission-Critical	19	19	28	10%
SSDs				
Server-Class	12	18	66	52%
Storage-Class	5	9	39	64%
Costs/GB				
HDDs				
Business-Critical	$0.03	$0.03	$0.02	-14%
Mission-Critical	$0.15	$0.12	$0.09	-13%
SSDs				
Server-Class	$0.42	$0.41	$0.12	-27%
Storage-Class	$0.58	$0.49	$0.15	-29%

Source: Gartner
Note: 1 Exabytes = 1 billion Gigabytes

15. Consolidating Data Centers Is Critical in All-Flash Array Pitch

Some corporations are using real estate consolidation and power savings to justify use of all-flash arrays that use expensive NAND memory-based storage. The densification and cost-reduction profile over the long term amid the rise of 3D-NAND also makes it an easier strategic path to follow vs. HDD's relative plateauing of density per platter. Nimble, Pure Storage and others also make it easier with management consoles, so much that the technical know-how required may not be as specific or significant. (10/13/17)

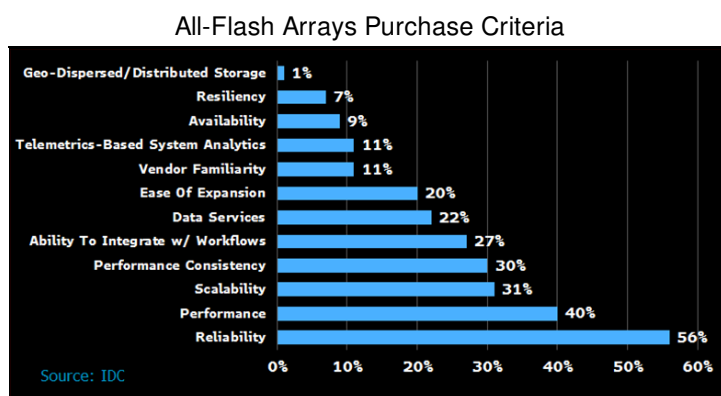Data Center Installed Base Forecast
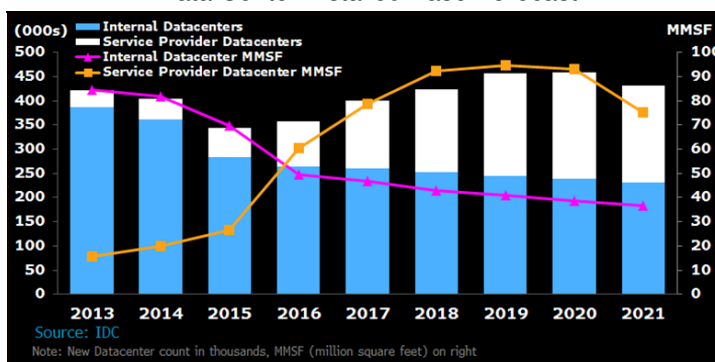
Source: IDC
Note: New Datacenter count in thousands, MMSF (million square feet) on right

16. Storage Software Pushes IT Buyers to Consider All-Flash Arrays

Better use of intelligent data compression, indexing and predictive analytics software is a key secondary reason IT buyers choose flash-memory based storage solutions. Enhanced performance is the primary driver, supported by power savings and compact size. Longer shelf life isn't as much of an advantage, as the technological progress and cost declines of flash storage are more pronounced vs. longer-lasting, higher-capacity hard drives. The latter are much cheaper, yet costs don't decline as steeply.

While these benefits are also available in hard drives from companies such as Seagate and Western Digital, the software enhancements coupled with the performance of all-flash arrays from NetApp and Pure Storage make these systems a compelling alternative. (10/13/17)

All-Flash Arrays Purchase Criteria

Criteria	Percent
Geo-Dispersed/Distributed Storage	1%
Resiliency	7%
Availability	9%
Telemetrics-Based System Analytics	11%
Vendor Familiarity	11%
Ease Of Expansion	20%
Data Services	22%
Ability To Integrate w/ Workflows	27%
Performance Consistency	30%
Scalability	31%
Performance	40%
Reliability	56%

Source: IDC

Topics 2

Hyperconverged Systems

Hyperconverged Systems' Scale Is Key to Address Larger Market

Sales of easy-to-use, cloud-friendly, hyperconverged systems are expanding, but they don't have the scale that simpler non-branded hardware or large branded vendor systems have established. Nutanix is the market-share leader for this gear, which combines computing and storage with software, but Cisco, HPE and NetApp are all growing. (10/16/17)

17. Hyperconverged, All-Flash Arrays Increasing in Private Cloud Use

Hyperconverged systems from Nutanix that include hardware, software and storage, or all-flash array storage systems from Nimble or Pure, offer increasingly popular alternatives to legacy systems sold by HPE or EMC, but are being used in private clouds. These models pitch scale-out or cloud-like capabilities, management simplicity and better software use to compress data or run servers more efficiently. When pitched with data-center consolidation, these new technologies may yield better performance and lower costs. (10/16/17)

Survey of Hyperconverged Replacing Legacy Systems
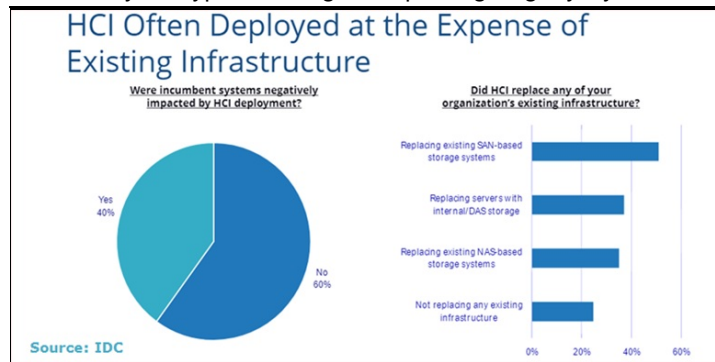
18. Analytics, Self-Healing and Scaling Drive Nimble, Kaminario

Analytics engines and self-healing software features, rather than over-engineered hardware redundancy, are efficient and now may be available at acceptable prices for many private clouds. These are key selling points for Nimble and Kaminario all-flash systems. Visibility of growth and diversity of data allow IT managers to scale hardware with agility. With compression software, the expensive yet fast flash-memory-based storage needed may also be lower than in legacy systems.

Rapid SSD densification, price declines, lower power consumption and lack of mechanical failures add to the attraction of these systems. Legacy products from EMC and NetApp are morphing their new systems to include these technologies and features. (10/16/17)

Nimble InfoSight Analytics Overview

19. Converged Gear May Limit Benefits of Private vs. Public Cloud

Converged and hyperconverged systems are expanding quickly in corporate IT as a way to replace legacy systems, because they're nimble and flexible, aptly suiting them for private clouds. Their gear is typically vendor-branded, custom and suited for a specific task, rather than disaggregated and commoditized. This potentially makes them unable to scale to match public clouds. Some systems are intended to scale-out to provide the cloud benefits, yet may not quite reach public-cloud scale or its cost profile.

Nutanix and Simplivity are leaders in the hyperconverged system market, while converged hardware is dominated by large systems makers HP Enterprise, Cisco/NetApp, EMC, Oracle and VCE. (10/16/17)

Nutanix Market Share vs. Addressable Market
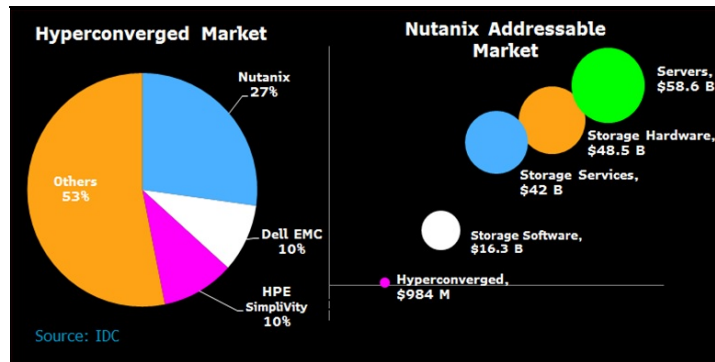
**Utopia vs. Reality of Hybrid Clouds**

Hybrid Clouds Are Software and Services Heavy, Harder to Set Up

Diverse hardware-system makers such as HPE, Dell/EMC and IBM are all pitching hybrid clouds as the best solution for corporations. The reality, though, is that it may be software and services oriented and more difficult to set up instead of easier, lower-cost public clouds or existing in-house systems. (10/06/17)

20. Hybrid Clouds May Well Be a Transitionary Step for Corporate IT

Private IT systems -- in discrete and cloud formats -- bridged by hybrid systems to rented IT on public clouds may be ideal for many companies, tying low cost and agility. The hybrid-cloud reality, however, is that it may be a stopover for corporate IT en route to using large-scale, efficient and flexible public clouds, yet retaining some IT on secure, inflexible but compliant in-house systems. Emerging IT gear such as hyperconverged and all-flash systems may not address broader tech architecture issues. (10/06/17)

IBM Hybrid Cloud Strategy
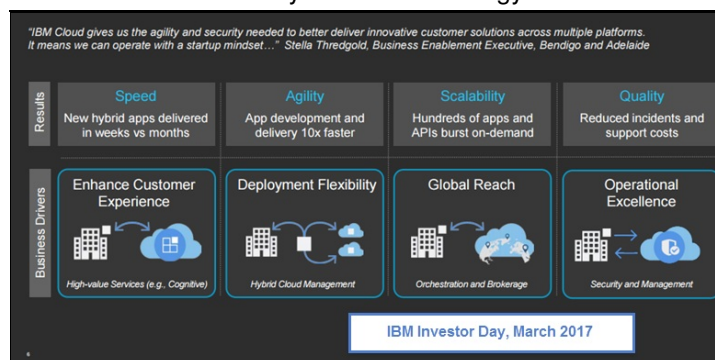
21. Hybrid-Cloud IT Skills Gap May Impede Rapid Adoption

Public clouds are popular because they're easy to use and lower in cost, while customized in-house IT is complex yet perceived as secure. Hybrid cloud is being pitched as middle ground to these two, but may need more IT skills to be rapidly adopted by the average corporation. Cost, technology and business features of all three models would need to be studied before in-house IT workers develop their ideal hybrid IT system. Even for large companies, this may be a hurdle, even more so for sub-scale IT systems.

Hybrid clouds may be more complex than private or public cloud systems, making the IT-skills gap wider than

current levels. This may slow hybrid-cloud adoption, driven by software and aided by services. It may also be heavily dominated by systems vendors such as IBM, HPE, NetApp and Dell/EMC. (10/06/17)

IDC Survey on Hybrid Cloud Strategy
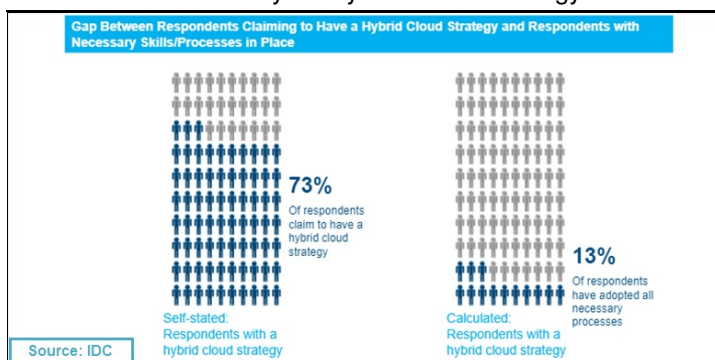
22. Composable/Disaggregated Gear May Be $45 Billion Market in 2020

The ability to create inexpensive, customized systems that include compute, storage and networking that efficiently match workloads remains several years away. Software layers needed to run these systems are in their early stages, as are advanced processors, particularly those that include networking features. Dubbed Composable/Disaggregated Architecture by IDC, this may be the next generation of public-cloud systems, with an addressable market of $45 billion in 2020.

Developments at part of the Open Compute project, and by vendors such as Microsoft, Facebook and Amazon.com, suggest a preference for such models. (10/06/17)

Composable/Disaggregated Addressable Market
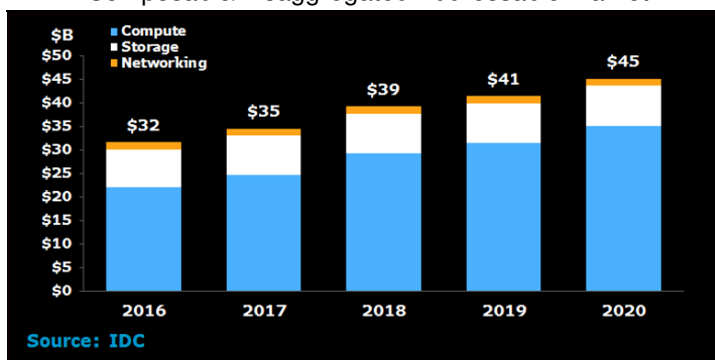

Beneficiaries of Hybrid Cloud

Microsoft, Oracle Are the Leading Beneficiaries of Hybrid Clouds

Microsoft is extremely well-positioned to benefit from hybrid clouds. Its well-entrenched corporate IT presence, the software-heavy nature of the hybrid cloud and the similarities of its public and private offerings of Azure makes for Microsoft's easy software connection between its two products. Oracle is another contender. (10/06/17)

23. Azure Stack May Ease Corporates' Cloud IT Pain and Costs

Microsoft's Azure may be a realistic bridge in hybrid-cloud adoption, as the familiar corporate IT provider offers cheap public clouds and similar features in a system that can be maintained inside corporate networks. The

Azure-in-a-box product Azure Stack, can have mirror environments inside the corporation and on its public cloud. Its platform includes HPE, Dell/EMC and nonbranded server and storage makers such as Quanta. This is an advantage for Microsoft over Amazon. (10/06/17)

Microsoft Azure Stack Architecture Summary
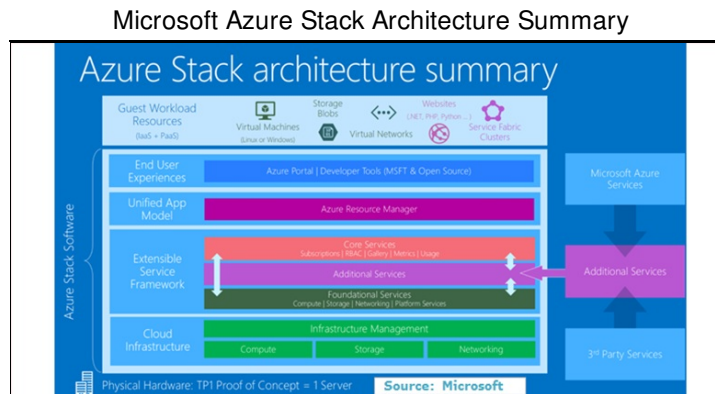
24. Hybrids Mostly Bridge In-House IT to Public Cloud Via Software

Hybrid clouds are likely to be a services-and-software model, not a hardware one. Data services for the hybrid cloud may grow 21% compounded annually, IDC data show. Services such as data integration and orchestration, security and compliance and data-location optimization may rise as part of a model that uses in-house storage and public-cloud gear. In moving hardware from corporate IT to the public cloud, sales compress and move to nonbranded vendors such as Quanta and away from the likes of HPE and Dell/EMC. (10/06/17)

Worldwide Data Services for Hybrid Cloud Revenue
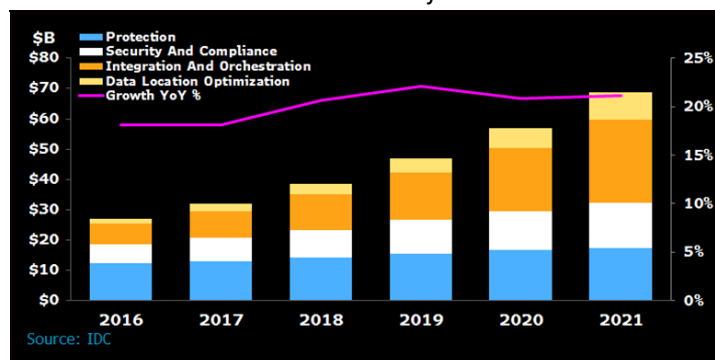

Amazon's Public Cloud

Public Cloud More Expensive Than Corporate IT at High Scale

Amazon.com's public cloud can become expensive to use and costly to exit, depending on the size and growth of a buyer's IT scale. Beyond a few hundred thousand servers, it may be cheaper to move IT back in-house. Amazon's value lies in its simplicity, which appeals to non-IT managers and to smaller companies. (10/16/17)

## 25. Amazon Lock-In May Be Concern for Advanced Cloud Buyers

NetApp is seeing a proliferation of the multivendor cloud model, as early buyers now match capabilities and costs to workloads. Just as one type of compute/storage/networking system doesn't fit all workloads, one cloud may not either. NetApp says that one-cloud models are moving into others and, in some cases, back to on-premise

designs. Some cloud apps, such as Drop Box, started out of Amazon.com and have since moved to in-house IT amid higher scale. (10/16/17)

IDC Survey of Reasons Customers Are Leaving AWS
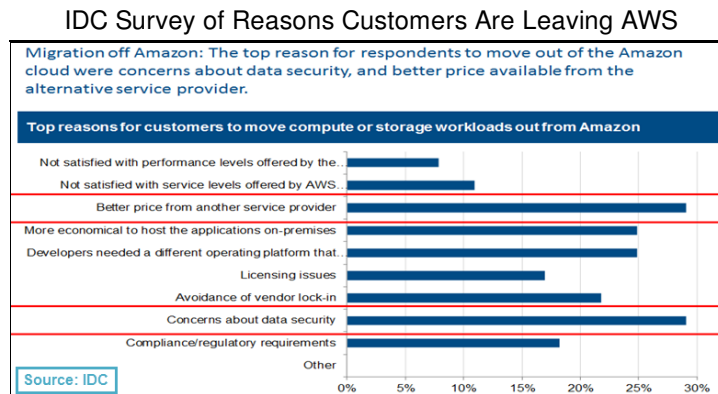
26. Cloud IT Buying Altering Customers, Changing Sales Pitches

Corporate IT's move to the cloud has changed who's doing the buying from gear vendors such as NetApp. The buyer is no longer a corporate IT infrastructure expert; now, it's a chief information officer, cloud and enterprise architect or development/operations professional who gauges solutions on business metrics, not system specs. To embrace that group, NetApp's sales process has greater education, trials and customer referrals mimicking cloud vendors' processes. This may also drive greater engagement and referrals. (10/16/17)

NetApp's Growing Customer Base
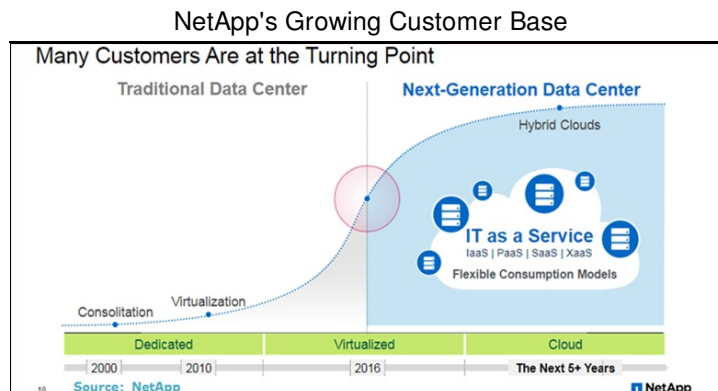
To contact the analyst for this research:
Anand Srinivasan at asrinivasan8@bloomberg.net