

Technology

Telecommute 101: the impact on networks, software, and applications

Industry Overview

Rise of the teleworkers redefines the enterprise network

As the COVID-19 virus forces Telecommute migration, we explore the implications for carriers, data centers, Enterprise networks, security, and applications. In the US alone, the Bureau of Labor Statistics estimates that 60% of the 118.3mn wage/salary workers could work from home in addition to the 5-7% that already have the capability. The resulting shift in traffic from office environments to home connections impacts the network, security, and collaboration choices that IT managers now face. Carriers like Verizon noted a noticeable spike in broadband traffic, stemming from VPN connections between homes and offices, increased gaming activity and over-the-top video services, yet the networks are robust and there are no reported US congestions at this point. However, on the enterprise side, we think the tsunami of remote workforce connections could put some strain on legacy network architectures, VPN connections, ADCs, collaboration tools and other network elements, which we discuss in this report.

Use of collaboration, video conference, UCaaS on the rise

Telecommute results in greater demand for video conferencing, Unified Communications as-a-service (UCaaS) and collaboration tools. CrowdStrike's CEO noted a 13% increase in productivity, utilizing Zoom to communicate with customers who are not travelling and are generally more available. We highlight Zoom, RingCentral, Cisco, and others as potential beneficiaries. We see greater adoption of as-a-service delivery mechanisms, which provide increased economics in distributed environments, while inherently solving delivery and interoperability issues. Software solutions have largely already gone this route, with security, conferencing, and certain aspects of traditional networking following the same path, in our view.

Security architecture must adapt with workers, apps

Our report discusses at length the connectivity options for remote workers and the security implications. Enterprises are experiencing a rise in VPN traffic and Virtual Desktop access, and the security/firewall architectures must support this shift in traffic. There are elevated Security concerns and a shift from protecting networks to protecting users, endpoints, and applications that operate from unsecured environments. This brings to front Zero Trust security frameworks, benefiting identity security companies like Ping and Okta, end-point companies such as CrowdStrike, who are also being asked to protect mobile environments now, and Cloud-based VPN alternatives from Zscaler and others.

We also highlight adjacent areas' respective beneficiaries

CDN companies like Fastly or Akamai are also potential beneficiaries given a greater need for content distribution and edge computing. Our report also discusses the potential rise in demand for Crisis Communications solutions from the likes of Blackberry and Everbridge; Data Center operators like Equinix, and compute-levered semiconductors such as Intel and Broadcom, among others.

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12114745

Timestamp: 23 March 2020 01:00AM EDT

23 March 2020 Corrected

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Referenced companies

Below are the Buy and Neutral rated covered companies that we highlight in our report as potential beneficiaries from the shift to remote working:

Table 1: Buy and Neutral rated covered companies who could benefit from the shift to remote working

Company	Ticker	Rating	Covering Analyst	Exposure to remote working
BlackBerry	BB	B-2-9	Daniel Bartus	Mobile Threat Defense solution helps secure new mobile devices; also a leader in crisis communications
Broadcom	AVGO	B-1-7	Vivek Arya	Leading networking silicon vendor to enterprise, hyperscale, and telco markets
CDW	CDW	B-1-7	Ruplu Bhattacharya	CDW helps organizations assess, implement and adopt WFH solutions
Cisco	CSCO	B-2-7	Tal Liani	Cisco's collaboration products (such as WebEx) directly address and enables remote working
Citrix	CTXS	B-2-9	Nikolay Beliov	Citrix's HVD software directly addresses and enables working remotely
CrowdStrike	CRWD	C-1-9	Tal Liani	Provides endpoint security
Everbridge	EVBG	B-1-9	Brad Sills	Provides crisis communications solutions
Equinix	EQIX	B-1-7	Michael Funk	Positioned to benefit from demand for distributed and connected compute based on global scale, multiple on ramps and connectivity
Intel	INTC	B-1-7	Vivek Arya	Leading server CPU vendor with fast growing networking silicon business
Netflix	NFLX	B-1-9	Nat Schindler	Global "stay-at-home" mentality shifts free time to streaming services
Palo Alto Networks	PANW	B-2-9	Tal Liani	Palo Alto's Prisma Access is a Secure Access Service Edge solution
Ping Identity	PING	B-1-9	Tal Liani	Provides Identity Access and Management solutions
RingCentral	RNG	B-1-9	Nikolay Beliov	RingCentral's Unified Communications as a Service platform directly addresses and enables remote working
VMware	VMW	B-1-9	Kash Rangan	Carbon Black provides endpoint security
Zoom Video	ZM	C-1-9	Nikolay Beliov	Zoom's unified communications platform directly addresses and enables remote working
Zscaler	ZS	C-1-9	Daniel Bartus	ZPA product directly address remote worker security

Source: BofA Global Research

Remote workforce 101

As part of the COVID-19 response, many employees across the US and Europe are shifting from working in office locations to working from home. This sudden shift in IT architecture has implications for security, networking, communications, and content delivery. Enterprise IT teams must navigate the changes by reconfiguring existing IT infrastructure to handle the shift and by adding new services focused on the remote worker use case. Service Providers must also make sure adequate bandwidth is available for residential networks operating at times previously considered off-hours. While we believe major trends such as cloud migration and employee mobility have helped prepare enterprise networks for such events, we highlight the key technologies that enable remote workers and the related spending considerations for Enterprises/Service Providers in this report.

What is a Virtual Private Network connection?

First, we provide the technology basics related to a remote workforce, beginning with one of the most common technologies: virtual private networks, or VPN. Virtual private networks (VPN) protect data through encryption, creating temporary "tunnels" across the web between two machines, such as the home and office. The encrypted tunnels create a safe and secure environment for corporate communications and data transfer regardless of the common internet infrastructure used, making VPN ideal for remote connections.

Specifically, the VPN process typically begins with a software program (or agent) installed on a corporate-owned device (or endpoint), such as a laptop. The VPN software agent runs locally on the laptop and makes a call back to the enterprise network after the laptop is connected to the internet. Data can then be transferred using a technique called encapsulation, where only the sender/receivers can access the content using decryption keys. In most remote worker use cases, this VPN connection is considered a one-way relationship where access is granted to the endpoint but new encryption keys are only generated by the VPN equipment located inside the enterprise network.

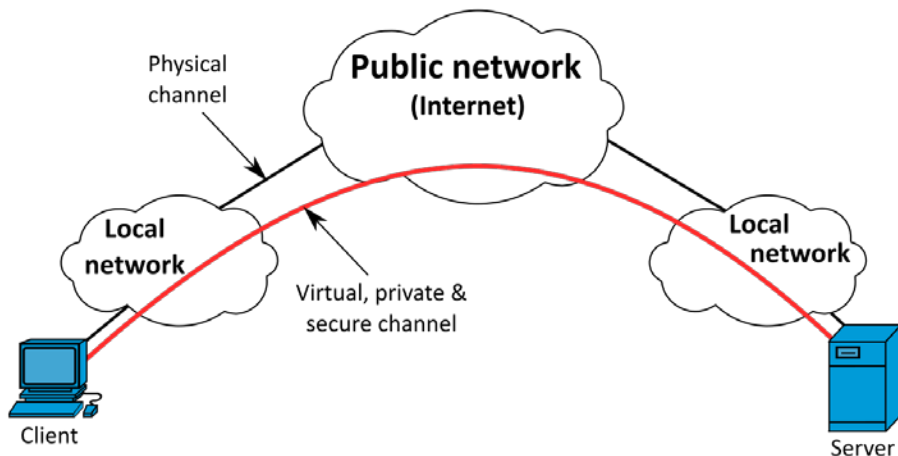
The encapsulation allows the data to safely travel over unsecured home Wi-Fi, Starbucks Wi-Fi, airport network, and more. Data also typically travels across the networks of local

Service Providers, such as Comcast, Spectrum, Verizon, etc (the process could also theoretically begin over the cellular network). Data, content, and instructions are then fully decrypted only by corporate firewalls or standalone VPN equipment. At last, the remote worker then has access to the enterprise network and the ability to use email, SharePoint, shared drives, internal applications, etc. When a file is retrieved from the corporate network, the process then works in reverse connecting again through the VPN.

SSL versus IPsec VPN

There are two categories of VPNs; Secure Sockets Layer (SSL) VPN vs. Internet Protocol Security (IPsec) in a firewall. The use case of remote worker described above, typically references an IPsec VPN. This connection allows a user to access the entire network, and the tunnel established can handle all IP traffic. A more flexible and granular VPN option is SSL, which eliminates the need for client endpoint management. For example, IPsec-based solutions would require a company-issued laptop, while SSL VPN software typically enables workers to bring their own device. With SSL VPN, a user would log into a web portal or browser application using authentication credentials. A similar tunnel would still be established between the secure web browser and the SSL VPN device that sits just inside the enterprise network. The SSL option allows for more versatility across endpoints (for example workers can use personal Mac devices) and can also limit the user to only accessing certain applications within the core network. While we believe the user experience with both options has improved in recent years, the VPN market is undergoing major changes and the COVID-19 virus could serve as a catalyst for new approaches, which we discuss in-depth in the below Security section.

Exhibit 1: VPN illustration



Source: CompTIA Security+ Deluxe Study Guide

What is a hosted virtual desktop?

Another common technology often associated with remote workforce access is a hosted virtual desktop (HVD). In this method, the user “dials” into the corporate through a regular browser, connecting to what looks to the user as his/her regular office windows desktop. In reality, the user dials into a virtual copy of the desktop that runs somewhere in the data center, which enables the user to access all of the services and applications normally accessed from the Office PC. Desktop virtualization refers to software, such as Citrix, that helps to make this connection. Another main benefit of a virtual desktop is the consistency of the users’ profile, applications, and configuration. HVD can help maintain that consistency across different devices and operating systems, such as mobile and MacOS.

Given that the virtual desktop technology is designed for user-specific consistency and access from multiple devices/locations, it naturally becomes part of many remote access strategies. For instance, the desktop environment can be accessed from an in-office PC running a thin client (basic software designed to connect to the centralized virtual

desktop) or any device that has an application or browser compatible to access the virtual desktop, such as an iPhone, iPad, or laptop.

Another common term discussed with HVD is Remote Desktop Service (or RDS). In this case, the centralized and virtualized desktops are shared across users. Rather than a user-specific desktop experience, RDS shares common environments for all workers. Both RDS and HVD benefit from storing all data on host computers, which helps for central management and backup. Importantly, remote workers use applications such as Citrix RemotePC to access the virtualized desktops, which create a “window” into the HVD environment for at-home connections. Large enterprises may offer a VPN strategy, remote HVD strategy, or both.

Focusing on Citrix, our view is that a spike in remote access could benefit the vendor in the near-term, but the company is going through a cloud transition with many moving pieces between offering its solutions via license, maintenance, and SaaS. It will be hard to see how the potential positive impact shows up in the numbers. Moreover, long-term competitive threats from Amazon, Microsoft, and VMware are not going away, but net, net the COVID-19 remote workforce impact could be a positive for the vendor in the near-term.

Similarly to Citrix, VMware’s EUC business (End User Computing) is going through a cloud transition (negatively impacting license revenues). Last fiscal year it grew product bookings by 20%+ and total bookings by low double digits, driven by the AirWatch mobility business, bundling with other VMware products, and share gains from Citrix, in our view. EUC should also benefit from increased demand for tele-working, but at around 15% of overall VMware revenues, it will be hard to move the needle on overall revenues.

Architecture choices: on-premise versus cloud

As part of the discussion of network constraints and capacity considerations as application use and locations shift, the basics of on-premise, private cloud, SaaS cloud, and public cloud are important. First, on-premise and private cloud generally relate to private data centers, commonly controlled, provisioned and managed by internal IT professionals. For instance, a large organization could deploy versions of collaboration software inside private data centers to maintain control and customized security architectures. A common example of this is a Microsoft Email Exchange server deployed in private data centers. In such cases, we generally see more risk of capacity constraints if on-premise software licenses are not built to scale with a sudden shift in demand (i.e., all teams using video conferencing versus select teams previously). On the other hand, SaaS offerings utilize the benefit of instant scalability of cloud networks, and can deliver services across geographies and time slots. We generally expect SaaS/public cloud to see more use but limited technical hurdles vs on-premise/private cloud deployments, potentially.

How must Enterprise IT teams respond?

Enterprise IT teams must rapidly shift to meet the demands of traffic coming from the remote workforce. As an example, this means provisioning firewalls to receive more traffic from disparate VPN connections rather than from branch and campus offices, and to prepare any SSL encryption termination technologies as well. We believe IT teams must also move to ensure on-premise/private cloud applications are provisioned to scale to changing needs. For instance, if a sudden surge in video conferencing sessions creates bottlenecks in the network/firewall and overburdens server infrastructure, new capacity and policies must be enacted. In our view, recent events are pushing IT teams to scramble to meet the network demands, create new interoperability across products for B2B connections, and make sure current product/architecture selections can scale with the growing remote workforce. During and following this sensitive time, we also believe the events could serve as a catalyst for Enterprise IT teams to assess new

products and reconsider architecture decisions, an opportunity discussed in detail in the below respective sections.

How must Service Providers respond?

Carriers have been leaning into the capacity demands related to remote workers: T-Mobile has announced that it will be bringing additional spectrum on line to facilitate incremental mobile demand. At AT&T and Verizon, over half of all post-paid phone customers are unlimited. AT&T has been bringing 60Mhz of additional spectrum on line related to its national FirstNet build and Verizon is deploying new mmWave spectrum in an additional 25 markets and increasing small cell deployment by 5x YoY. Last week, Verizon announced it would raise capex by a mid-point of \$500m from prior guidance (3%).

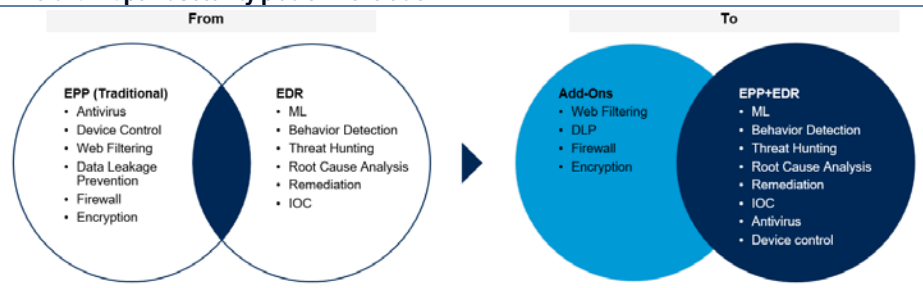
On the wireline side, carriers are clearly comfortable with capacity capabilities as AT&T and Comcast both announced they would be loosening capacity caps for broadband connections and Comcast also announced it would be allowing all users to access its network of WiFi hotspots. Additionally, Cox Communications stated it would automatically upgrade users with speeds of 30 MB/s, to packages with 50 MB/s. Verizon and Charter are also able to increase network capacity with additional equipment and strategies used during natural disasters, if needed. Our conversations with company management teams have been widely upbeat about network capability and the opportunity to enable the remote workforce.

Securing the remote workforce

Deploy and secure new endpoints

Moving employees from an office setting to working from home requires additional security measures. First, remote workers often require company-issued devices, such as a laptop, tablet, or smartphone. These devices, or endpoints, require provisioning and security software installed locally. The local software, or agent, then applies security detection, prevention, and policies while also communicating back to the IT Security team and increasingly backend intelligence in the cloud to stop malware/attacks. We note that large enterprises may have 10+ security vendors providing some sort of endpoint security, ranging from application whitelisting and data loss prevention to antivirus and advanced threat protection, which can make the provisioning of new devices a cumbersome process. However, at the same time, the market is shifting to converge these functions under two umbrellas: Endpoint Protection Platforms (EPP) and Endpoint Detection and Response (EDR), partly in an effort to consolidate vendors/agents. These two Endpoint Security categories are also now further converging into what is dubbed Unified Endpoint Security (UES) platforms.

Exhibit 2: Endpoint Security platform evolution



Source: Gartner

We see the sudden surge in remote workers likely requiring more corporate-issued devices and potentially serving as a catalyst to adopt new leading Next-Gen UES vendors. In particular, we highlight Buy-rated CrowdStrike, given the vendor's broad platform offering with 10+ endpoint services and the ability to rapidly deploy across thousands of devices. Its light-weight single agent also helps the performance of corporate-issued laptops versus agent-bloat (from too many vendors) that can hurt the

user experience. We also flag Blackberry's Cylance as well-positioned to secure new devices, particularly new mobile devices given Blackberry's recent integration of Cylance into its legacy Endpoint Mobility Management (now dubbed Mobile Threat Defense). VMware's Carbon Black/AirWatch assets are also well-positioned along with market leader Microsoft.

Exhibit 3: Endpoint Protection Platform leaders



Source: Gartner

Implement a remote access/VPN strategy

Remote worker endpoints must then be connected to enterprise applications securely. As discussed in the above introduction, secure remote connections are usually accomplished by using a VPN, remote desktop, or browser isolation technologies.

Standalone SSL VPN: a market in transition

SSL VPN is a \$402mn market segment that grew 8% in CY18 after flattening trends in recent years. We anticipate this standalone category will face secular declines as it increasingly becomes integrated into either firewall appliances or endpoint management offerings (as is the case with Cisco AnyConnect). For instance, Palo Alto's firewalls have historically provided customers with capabilities to operate 20,000 SSL VPN users via an additional subscription. The firewall or any perimeter device is a strategic location to apply encryption technologies given it is the first/last device to touch traffic traveling in/out of the enterprise network. However, encryption can also drain compute resources on firewalls, and therefore some VPN technologies can be used in conjunction with proxy equipment for decryption from the likes of F5 or Citrix, for instance.

Table 2: VPN market trends and share

	1Q18	2Q18	3Q18	4Q18	1Q19	2Q19	3Q19	CY15	CY16	CY17	CY18
Cisco	6.3	6.8	7.4	8.0	4.7	4.8	4.8	39.1	38.1	35.0	28.6
YoY Chg	-34.7%	-28.7%	-12.7%	10.2%	-24.9%	-29.8%	-34.3%	-19.6%	-2.7%	-8.0%	-18.4%
% of Total	7.0%	6.7%	7.3%	7.4%	4.8%	4.9%	5.0%	10.7%	10.2%	9.4%	7.1%
Check Point	13.5	13.4	13.0	14.4	13.9	13.3	13.7	58.2	65.6	63.6	54.4
YoY Chg	-12.3%	-14.9%	-18.9%	-11.7%	2.5%	-0.6%	5.3%	0.5%	12.7%	-3.1%	-14.4%
% of Total	15.0%	13.1%	13.0%	13.2%	14.1%	13.6%	14.1%	16.0%	17.6%	17.1%	13.5%
Huawei	4.1	6.0	6.0	9.6	4.9	6.1	6.3	5.9	11.2	18.1	25.7
YoY Chg	69.7%	60.8%	38.5%	26.6%	19.6%	1.0%	6.1%	-30.0%	89.5%	61.8%	42.3%
% of Total	4.5%	5.9%	6.0%	8.8%	5.0%	6.3%	6.5%	1.6%	3.0%	4.9%	6.4%
Citrix	15.6	16.0	16.5	17.0	16.5	16.0	15.5	61.9	59.8	58.3	65.1
YoY Chg	13.1%	14.0%	15.0%	6.0%	6.0%	-0.2%	-6.0%	6.7%	-3.4%	-2.5%	11.8%
% of Total	17.2%	15.7%	16.5%	15.6%	16.8%	16.4%	16.0%	17.0%	16.1%	15.7%	16.2%
Array Networks	10.5	10.8	11.1	11.5	11.1	10.8	10.5	49.2	45.4	41.4	43.8
YoY Chg	5.2%	6.1%	7.1%	4.9%	6.0%	-0.2%	-6.0%	6.0%	-7.9%	-8.7%	5.8%
% of Total	11.6%	10.6%	11.1%	10.5%	11.3%	11.0%	10.8%	13.5%	12.2%	11.1%	10.9%
Other	40.3	48.8	46.4	48.7	47.0	46.6	46.1	150.1	152.3	155.7	184.2
YoY Chg	11.2%	29.3%	14.8%	17.8%	16.6%	-4.5%	-0.5%	-0.7%	1.4%	2.3%	18.3%
% of Total	44.6%	47.9%	46.2%	44.6%	47.9%	47.7%	47.6%	41.2%	40.9%	41.9%	45.8%
Total	90.3	101.9	100.4	109.3	98.1	97.6	97.0	364.5	372.3	372.0	401.8
YoY Chg	3.2%	11.9%	6.8%	9.8%	8.7%	-4.2%	-3.4%	-1.9%	2.1%	-0.1%	8.0%

Source: Informa

Question of Zero Trust versus Castle and Moat

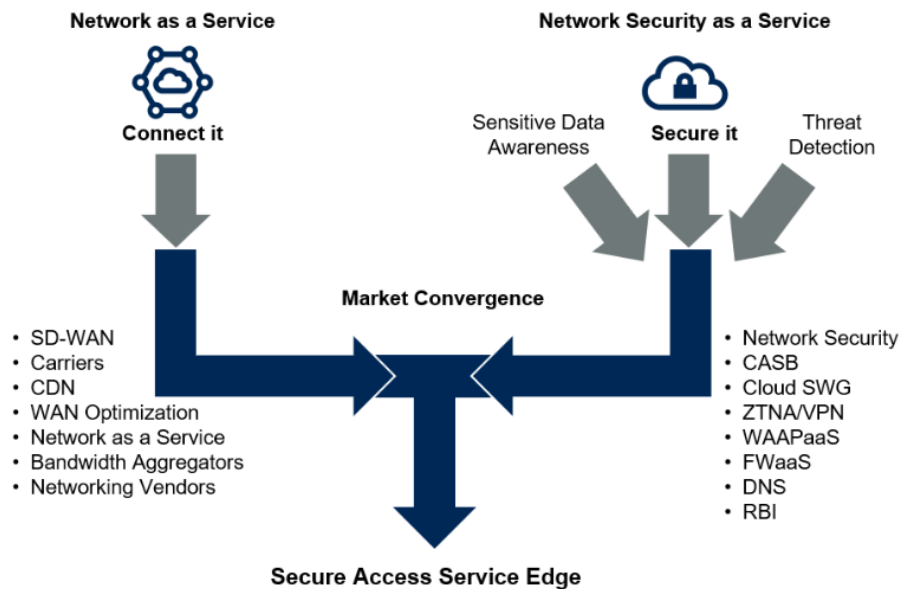
We flag that both legacy standalone VPN technologies and VPNs delivered through firewall devices are examples of classic “Castle and Moat” security architectures. In such strategies, the enterprise network and applications are protected by a perimeter, or moat, that requires user authentication to enter. The ‘Castle and Moat’ (or legacy) architecture is breaking down and giving way to ‘Zero Trust’ security architecture. Legacy architecture is broken because of three trends, in our view: 1) hackers can easily bypass perimeter technologies and then appear as ‘trusted’ activity, 2) users are increasingly mobile, making routes back to the enterprise network inefficient, and 3) applications are shifting from inside the enterprise network to SaaS and public clouds. We believe these trends require new security and networking strategies and a surge in remote workers could expose the need to adopt new architectures.

An alternative framework is related to Zero Trust and cloud security. In Zero Trust, all transactions must be authenticated. This means that rather than assuming all traffic behind the firewalls is safe and inside the organization, all transactions are instead required to pass through additional security screening. We highlight Zscaler’s Private Access (ZPA) as an attractive VPN alternative that adheres to a Zero Trust model.

Cloud-delivered security makes sense for remote workers

Traditional remote workforce technologies such as VPN are also set to decline due to inefficiencies inherent in the architecture. Gartner estimates that by 2023, 60% of enterprises will phase out VPNs for zero trust network access, or ZTNA. For simple demonstration of such potential inefficiencies, take a mobile user accessing the Microsoft Office 365 SaaS offering, for example. In a legacy Castle/Moat and VPN architecture, the user may be in San Francisco and be required to create a secure VPN tunnel to a private data center in Washington DC. After the traffic travels all the way to Washington DC, it may then go through a stack of security equipment (inside the DC data center) to ensure it is to be trusted and safe of malware. However, this request may then ultimately have to go back out to the open Internet to access the Microsoft data center which could be all the way back in San Francisco. This inefficient route could add latency, erode the user experience, and consume excess bandwidth of costly security and networking devices in the private data center. The inefficiency is only amplified when legacy VPNs send all traffic through this architecture, including non-critical traffic like YouTube video streaming.



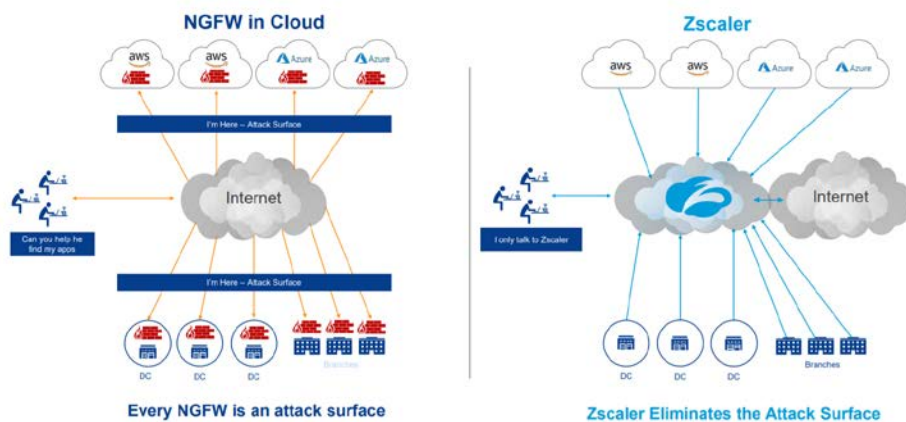
Exhibit 4: Convergence of Network and Security into Secure Access Service Edge (SASE)

Source: Gartner

To counter the network/security inefficiencies that rise from cloud application usage and a mobile workforce, new areas of cyber security are emerging such as a Secure Access Service Edge (SASE) or cloud-based Zero Trust Network Access (ZTNA). Again we flag Zscaler's ZPA as an attractive service that addresses both use cases. Palo Alto's Prisma Access, Check Point's CloudGuard, Cisco's Umbrella, and Akamai's Enterprise Application Access are also increasingly addressing this shift.

To illustrate the difference with new cloud-delivered offerings, reconsider the mobile worker in San Francisco now using Zscaler. This employee may be on a corporate or personal device which is configured to send traffic to Zscaler's cloud through a thin software agent. Zscaler's cloud (which ideally is close to the user in San Francisco) processes the traffic and determines where it is meant to go. It also applies deep threat inspection and authentication services. If it is Office 365 traffic, Zscaler's cloud connects directly with Microsoft's cloud via a secure route. If it is traffic related to an internal enterprise application only residing in the Washington DC data center, the Zscaler cloud would authenticate the request and securely connect it to the internal infrastructure. The benefit is a better user experience, easier security management, and less traffic (especially unnecessary traffic) flowing through the costly private data center.

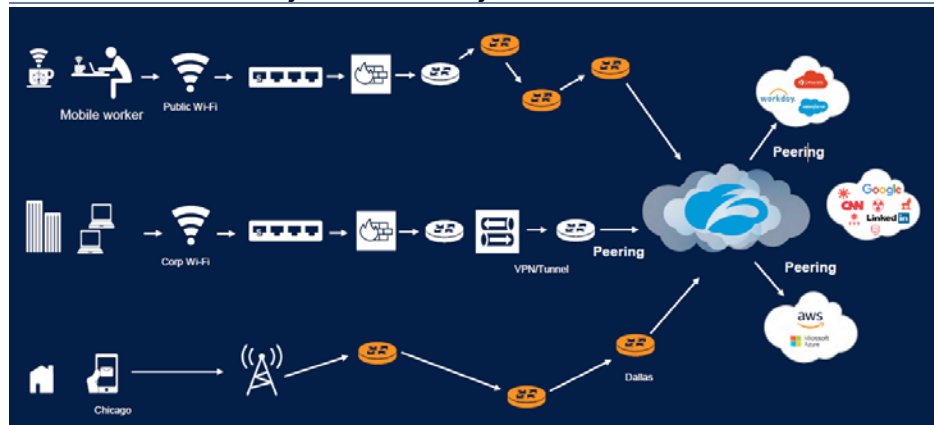
We believe ZPA represents a meaningful incremental opportunity, and our view is supported by four key points: 1) ZPA is already contributing 14% of Zscaler's new business and 13 of Zscaler's top 25 customers have adopted the service, 2) the ARPU opportunity is typically equal to the core ZIA opportunity, per management, 3) we estimate the enterprise SSL VPN market size at roughly \$500mn+ today (when considering that it is typically lumped with the firewall and endpoint markets) and ZPA addresses much more than VPN, and 4) Zscaler has seen ZPA traffic increase 3x globally since the coronavirus outbreak.

Exhibit 5: VPN and firewall disruption in a Zero Trust architecture

Source: Zscaler

Remote worker traffic travels over a black box

Lastly, we note that while enterprises often trust the open Internet and Service Provider networks (especially given new encryption tools), such networks remain a black box for IT teams. For instance, if a remote user is upset with a poor user experience, it may be difficult to diagnose the problem which could be related to the device, home network, local service provider network, internal data center infrastructure, or the applications scattered across multiple clouds. As such, we see a need in the market for a middleman service to detect the performance across this chain and provider network visibility. Again, Zscaler is potentially well-positioned with its new Zscaler Digital Experience (ZDX) offering, scheduled to ramp in CY4Q20. ZDX directly addresses this black box problem by giving IT teams insight into the user experience down to the level of the device, local network and application geography.

Exhibit 6: Cloud-based security built to address any connection and location

Source: Zscaler

In summary, we see the pickup in remote workers requiring some additional endpoint security, VPN or Zero Trust access technologies. These trends may be somewhat negative for firewalls, in our view. VPN use may require some additional licenses from firewall vendors at first, but we see potential for some situations where the increased burden on firewalls and necessary SSL termination could impact performance. The trends also generally steer traffic away from the old networking routes and use of firewalls in campus/branch offices (where users had been sitting) and shifts traffic to different data center firewalls or new competing firewall-as-a-service cloud offerings. Firewall vendors must address these changes by aggressively competing in the SASE market.



Other areas of security may be less impacted. For instance, identity remains critical in a Zero Trust world, but the spending and technologies act similarly no matter if workers are in the office or remote. On the margin, there may be some increased interest in behavioral analytics around identity (ie. Device type, location, etc.). Interest in multi-factor authentication (MFA) for additional identity security may also increase.

Separately, email and messaging security continues to play a vital role, but with 75% of email security already delivered as cloud-based security, we do not see major changes based on the location of workers.

Applications enabling remote workers

Collaboration and Unified Communications

In our view, the Covid-19 tragedy has reinforced the value proposition of the overall enterprise cloud-based communications and collaboration space, and especially the platform vendors (Zoom Video, RingCentral). These solutions were designed 10+ years ago with several secular trends in mind: cloud, mobility, remote working, Millennials, and ease of use, while driving much lower cost of ownership and enabling new functionality only made possible due to cloud-based architectures.

Lower cost of ownership is driven not just by replacing the prior generation hardware-based systems, but also by consolidating multiple point products such as voice, text, fax, audio conferencing, video conferencing, and chat-based collaboration. In other words, these are true cloud-based platforms that have re-imagined traditional telco-based functionality into software.

From software development point of view, to be able to deliver quality and reliable communications services in the cloud, requires a sophisticated software stack that is much more complicated and unfamiliar territory to traditional SaaS/on-premise companies: connectivity layer (cloud and PSTN) + infrastructure + application services + user experience. This opened up space for several smaller, fast growth, visionary companies that specialize in different segments of the cloud communications market, which are on their way to build true platforms at scale (RNG, ZM).

What we find quite appealing in this market is that the mega vendors (Cisco, Microsoft, Avaya) have not been able to either transition to the cloud and/or have a mixed success. They have adopted different strategies – for example hosted models (Cisco), partner with a cloud provider (Avaya), or pick a niche area to compete in the cloud (Microsoft Teams competing with Slack).

Workforce dynamics have been changing to a more mobile and distributed work place, accelerated by Millennials becoming a significant portion of the overall workforce as many of these users require flexible, reliable, mobile-first communications services that the legacy providers are not able to provide. These users also live in an app-centric world, driving the need for embedded communications in mobile apps.

With 400mn+ knowledge workers globally and less than 20mn on cloud and hosted solutions, the market opportunity is in the very early innings. Millennials currently make up 35% of the US workforce and are likely to reach 50% of the workforce in two years and reach 75% by the year 2030. The millennial population values flexibility and mobility in their work environment and needs effective ways to communicate beyond in-person meetings.

COVID-19 should accelerate adoption of these platforms as all companies realize they need to roll out business continuity solutions for tele-working, and vertical use cases such as tele-medicine, tele-education, etc become more widely adopted.

UCaaS has crossed the chasm

We believe that UCaaS (unified communications as a service) has crossed the chasm with UCaaS at about 10% of the market driven by: 1) UCaaS being a critical piece in the system of engagement and customer engagement; 2) as customers upgrade from on-

premise sales, service, marketing, and ecommerce applications to SaaS, it creates a pull-through for UCaaS; 3) PBX replacement; 4) increasingly mobile workforce. The incumbents have been slow and/or unsuccessful adopting the cloud, creating space for several pure play UCaaS companies such as RNG and ZM.

UCaaS integrates voice, voicemail, instant messaging, e-mail, presence, audio conferencing, video, and call center on a single platform. UCaaS can be delivered as an application in a device in a location-agnostic way. This ease of use and portability is very appealing to businesses and helps increase worker productivity and improve customer interactions.

The average life of a telephone system is eight years, and many were updated in the year 2000 given the Y2K issue. The 2008 replacement cycle coincided with the recession when capex budgets got hit. As a result, the market has a large installed base of systems that are 10+ years old. Those systems are not designed to handle a mobile and distributed workforce and lack key features.

The move to the cloud in hardware and software has already demonstrated to businesses the benefits of opex-based vs. the traditional capex-based IT models. And, the adoption of smartphones could leave businesses hamstrung in providing a similar consumer experience in the workplace. Now, businesses can adopt an opex-based, predictable cost approach in their telecom systems.

Zoom Video

Zoom Video, ticker ZM (Buy; PO: \$140), is the beneficiary of multiple long-term secular trends that are driving the notion of video as the new voice. Video communication is increasingly accepted by customers and employees as the “new normal”, although it is still in the early stages. Zoom has expanded its capabilities beyond video conferencing to a platform solution that includes audio, chat, webinars, conference room connectors, and most recently voice/cloud phone system (Zoom Phones).

The company is well-suited to replace legacy video conferencing (i.e. Cisco WebEx, LogMeIn, etc.) and is expanding the video communications market as it changes the culture and how people collaborate – “video is the new voice”. Zoom is a disruptor in the market from a technology and pricing point of view: 1) MMR and video-first technology allowing up to 45% data loss without impact to video quality and 2) low pricing of \$15-19/user/month and is compatible with third party hardware, allowing customers to leverage existing hardware investments and therefore lowering switching costs.

Impressively, Zoom can handle up to 45% packet loss (i.e. data loss) without impact to video quality and a single session can handle up to 160,000 users. This feat is a result of Zoom’s real-time video-first architecture with multi-media routing (MMR), a key technological differentiator, which we think puts Zoom in a strong lead and represents a barrier to entry. We believe that existing video companies would need to completely rebuild their technology to compete on video quality and reliability. Furthermore, Zoom’s fast innovation and DevOps culture should support continued technological superiority over competitors (200+ features added per year, minor releases every few weeks and major releases every two months).

RingCentral

RingCentral (RNG; Buy; PO: \$215), has built a best in class unified communications solution for enterprises in the cloud. RNG’s cloud PBX system is seen by partners and customers as the gold standard, validated recently with the Avaya partnership, and RNG combines this with best in class contact center and video conferencing solutions via its partnership with NICE InContact and Zoom. The entire RNG technology suite is well suited to displace the existing 400mn+ installed legacy seats (i.e. Avaya, Cisco, Mitel, NEC, etc.). At only ~2mn seats today, RNG has a long runway for sustained growth. What is underappreciated about RingCentral is that customers often consolidate multiple solutions and significantly simplify their communications infrastructure when they



deploy the RingCentral platform – voice, web conferencing, audio conferencing, collaboration, and also call center. As a testament to why RingCentral is considered the gold standard in UCaaS – the next two competitors combined have the same revenue scale but are growing at half the revenue growth rate.

In our view, RNG is the gold standard in UCaaS (unified communications as a service) across the entire value chain – technology, product, open platform, integration with other vendors, professional services, partner enablement, and customer success. RingCentral's platform offers a cloud-based solution for business communications that replaces legacy and expensive on-premise communications systems. It is delivered as an application that is accessible to the user regardless of device (i.e. office phone, smartphone, desktop, tablet). Communication capabilities include team collaboration, voice, chat, fax, audio conferencing, and deep integration with document and customer relationship management systems. RingCentral also offers contact center and video conferencing solutions through its partnership with best in class companies InContact and Zoom, respectively.

At RNG's analyst day in June 2018, the company revealed that within the top 15 customers (by number of seats) most use mobile (11/15), team messaging (10/15), and video (12/15), while 50%+ use contact center (8/15) and platform (9/15). Usage outside of voice grew triple digits in 2017: 40% voice minutes, 100%+ API calls on the platform, 110% video minutes, 115% messaging posts, 150% mobile minutes, and 240%+ call center. A panel of large customers further demonstrated multiple reasons why RNG wins: complexity of legacy systems, consolidation of multiple solutions on RNG's platform, call center capability, reliability and quality of phones, increasing millennial workforce, modern consumer-like experience, high return on investment, operational efficiencies, and the breadth and depth of integrations with third party enterprise software solutions

Cisco

In our view, Cisco (CSCO; Neutral; PO\$47.0) is also a beneficiary of the workforce transitioning to working remotely as the incumbent Unified Communications provider with its broad portfolio of telepresence, conferencing, Voice, and collaboration solutions. Collaboration solutions accounted for 9% of Cisco's FY17 revenues, or roughly \$4.3bn, and despite the entrance of newer cloud-based names, we note that Cisco's solutions are deeply entrenched in large Enterprises and financial institutions. Although Cisco's WebEx solution could be considered a "legacy" conferencing tool, new features and products are added, such as video-conferencing. Lastly and most importantly, we note that newer cloud-based names such as Zoom may not have the infrastructure to handle a significant increase in user traffic in all regions throughout the day versus Cisco.

Networking impact from remote workers

As Enterprises across the globe are rapidly requiring employees to work from home as COVID-19 spreads, we discuss the impacts on the network.

At home versus at work: implications for service providers

In our view, Service Providers will not need to increase network capacity dramatically to support workforces moving to work from home models. Despite employees moving physical locations, we note that the amount of bandwidth on the network does not change. Traffic on the network at Enterprise locations will be decreasing, versus typically experiencing high volume between standard work hours of 9:00am-5:00pm, whereas home networks that typically experience high levels of traffic after 5:00pm will now experience high traffic volumes throughout the day. Put simply, traffic on the network is shifting locations and times, and the reported 30% increase in traffic could be handled by the existing infrastructure. Verizon recently noted that the company is only seeing pockets of increased data usage within areas heavily impacted by the virus. We do not expect this trend of working from home to constrain the network in metro locations, where Enterprise and Home networks are co-located.



Another aspect for consideration is the legacy MPLS services. MPLS is the enterprise networking workhorse. While there is widespread recognition that MPLS is transitioning to SD-WAN, like Cloud migration, enterprises generally are taking a hybrid approach to network migration and expansion. Remote telework will stress enterprise VPNs and could cause IT teams behind the curve to chase additional MPLS capacity from carriers but we believe this capacity is available to be had. Looking ahead, we are not of the view that this short term need for capacity enhancement at the enterprise level will change the strategic hybrid approach most enterprises are taking.

ADCs and virtual desktops

ADC boxes serve one of two purposes: 1) configuring enterprise applications deployed in enterprise data centers, and 2) providing load balancing for various carrier services. The hardware ADC market, mainly composed of vendors F5, Citrix, and A10, has been contracting for the last two years as enterprises move to virtual (software) ADC deployments and shift their workloads from on-premise into the cloud, or a hybrid network. Since ADC boxes are priced by fixed capacity, they are unable to dynamically increase capacity if the cap is reached. This facilitates a widespread over-provisioning of capacity, as enterprises would rather over-provision networks rather than run the risk of surpassing capacity limits, with some enterprises utilizing as little as 10% of appliance capacity. Hardware appliances make up 62% of the ADC market, which grew 12% and 13% in 2018 and 2019, respectively. Alternatively, newer vendors such as Avi Networks are offering cloud-based ADC solutions that function as load balancers with the option to turn on other functions and services, such as traffic analysis, security services, WAF, and dynamic application patching, as an alternative to sitting a virtual machine next to a virtual ADC, and these solutions are able to be spun up and down on a per-instance basis. The market for ADCaaS is ~10% of the size of the total ADC market, and grew 38% in 2019 (see Table 3).

Table 3: Sizing the ADC market

	17-Mar	17-Jun	17-Sep	17-Dec	18-Mar	18-Jun	18-Sep	18-Dec	19-Mar	19-Jun	19-Sep	19-Dec	CY2017	CY2018	CY2019
Total ADC market (mn's)	\$469.4	\$454.5	\$468.9	\$469.5	\$450.0	\$445.6	\$458.2	\$437.5	\$409.5	\$419.1	\$456.8	\$440.8	\$1,862	\$1,791	\$1,726
QoQ	-3.1%	-3.2%	3.2%	0.1%	-4.2%	-1.0%	2.8%	-4.5%	-6.4%	2.4%	9.0%	-3.5%			
YoY	-2.9%	-7.5%	-6.6%	-3.1%	-4.1%	-2.0%	-2.3%	-6.8%	-9.0%	-5.9%	-0.3%	0.8%	-5.1%	-3.8%	-3.6%
Hardware	\$344.2	\$331.4	\$337.7	\$334.3	\$314.7	\$303.2	\$309.3	\$287.2	\$265.6	\$263.5	\$281.9	\$265.5	\$1,348	\$1,214	\$1,077
QoQ	-4.5%	-3.7%	1.9%	-1.0%	-5.9%	-3.6%	2.0%	-7.2%	-7.5%	-0.8%	7.0%	-5.8%			
YoY	-5.4%	-9.7%	-8.9%	-7.2%	-8.6%	-8.5%	-8.4%	-14.1%	-15.6%	-13.1%	-8.9%	-7.5%	-7.8%	-9.9%	-11.3%
Virtual	\$125.2	\$123.1	\$131.2	\$135.2	\$135.3	\$142.4	\$148.8	\$150.3	\$143.9	\$155.6	\$174.9	\$175.3	\$515	\$577	\$650
QoQ	0.8%	-1.7%	6.6%	3.0%	0.1%	5.3%	4.5%	1.0%	-4.3%	8.1%	12.4%	0.2%			
YoY	4.6%	-1.1%	-0.3%	8.8%	8.0%	15.7%	13.4%	11.2%	6.4%	9.2%	17.5%	16.6%	3.0%	12.1%	12.6%
Application Delivery as a Service (mn's)					\$17.5	\$18.4	\$19.7	\$22.1	\$23.5	\$24.3	\$26.8	\$32.9		\$78	\$108
QoQ						5.1%	7.4%	12.1%	6.5%	3.2%	10.5%	22.7%			
YoY									34.7%	32.3%	36.1%	49.0%			38.6%

Source: BofA Global Research, IHS Markit

While there is a low barrier to entry for newer ADC vendors, we note that replacing an incumbent ADC vendor involves re-architecting application configurations, which is expensive and labor-intensive. Many large Enterprises and financial institutions remain with incumbent ADC vendors for this reason, and we expect that a significant amount of the network traffic involved with working from home for Fortune 500 companies will likely rely on solutions from F5 or Citrix for load balancing. We note that load balancers will likely experience the highest amount of network traffic at peak connection hours (such as first thing in the morning), although once each network session has been established, its relative "load" on an ADC vendor decreases.

WFH trend could drive a home network upgrade cycle

Notably, a key piece of the remote worker experience is the quality of the in-home Wi-Fi network. If multiple members of a household connect to the network, all using different web applications and streaming media (Spotify, Hulu, Netflix, Zoom, etc), this could put a strain on the Wi-Fi network that has never been experienced before. In our view, this could catalyze either full or partial (Wi-Fi extenders or mesh networks) network upgrades



especially in areas significantly impacted by the virus (San Francisco, New York) where household members are unable to leave the home. We provide a snapshot of the Consumer Wi-Fi market below, which is expected to grow from ~\$3.5bn in 2019 to +\$5bn by 2023. The total market consists of Wi-Fi routers, home access points, broadband gateways, and Wi-Fi extenders. Wi-Fi routers serve as replacements to carrier home gateways, and broadband gateways exist as “BYOD” solutions versus having to rent a modem from a service provider for a monthly fee. Home access points and Wi-Fi extenders work to extend the “reach” of the Wi-Fi and to optimize and manage the network.

Table 4: Snapshot of the Consumer Wi-Fi market (\$K)

	2017	2018	2019	2020	2021	2022	2023
Wi-Fi routers	\$2,315,373	\$2,048,551	\$1,774,937	\$1,804,438	\$1,778,671	\$1,760,254	\$1,746,170
YoY growth		-11.5%	-13.4%	1.7%	-1.4%	-1.0%	-0.8%
Whole home systems access points	\$442,288	\$621,694	\$837,770	\$1,164,911	\$1,561,463	\$2,042,015	\$2,503,762
YoY growth		40.6%	34.8%	39.0%	34.0%	30.8%	22.6%
Broadband gateways	\$761,056	\$580,285	\$519,821	\$489,716	\$489,953	\$487,665	\$490,724
YoY growth		-23.8%	-10.4%	-5.8%	0.0%	-0.5%	0.6%
Wi-Fi extenders	\$431,708	\$412,036	\$422,108	\$436,402	\$434,806	\$476,138	\$536,992
YoY growth		-4.6%	2.4%	3.4%	-0.4%	9.5%	12.8%
Total Consumer Wi-Fi market	\$3,950,426	\$3,662,566	\$3,554,636	\$3,895,466	\$4,264,893	\$4,766,071	\$5,277,648
YoY growth		-7.3%	-2.9%	9.6%	9.5%	11.8%	10.7%

Source: BofA Global Research, IHS Markit

While some of this decision to upgrade the home network is dictated with modem interoperability with the cable/telco provider, in most cases we see a plethora of new Wi-Fi mesh offerings that are universally compatible, with CommScope, Ubiquiti, Netgear, and more offering consumer Wi-Fi solutions. In addition, we believe that Service Providers may be incentivized to more quickly deploy mmWave spectrum and provide fixed wireless access solutions to handle the increased network traffic and bandwidth requirements. Of the US carriers, Verizon has been the most vocal regarding 5G fixed wireless initiatives, and we note that Verizon recently increased its CY20 capex budget by \$500mn at the midpoint to accelerate network investment. T-Mobile began 5G fixed wireless trials in March 2019. AT&T currently has a fixed wireless offering which operates over its 4G/LTE network, and plans to roll out fixed wireless over 5G.

Lastly, we note that modems, Wi-Fi extenders, and fixed wireless access devices all contain semiconductors made by companies such as Broadcom, Intel, and more, and point investors to page 16 for Semiconductor Analyst Vivek Arya’s coverage implications.

Adjacent technology areas also impacted

CDN and Edge Cloud providers increasingly important to offload traffic

With more workers staying at home, we expect that CDNs (vendors such as Fastly, Akamai, Cloudflare, etc) will play a crucial part in delivering traffic. The \$12.4bn CDN market is driven by the growth of Internet traffic and data consumption, as well as growth in the consumption and distribution of media content, such as streaming audio and video. The rise of over-the-top (OTT) content is a driver for the CDN market as well, with CDN providers supporting OTT companies such as Netflix, Hulu, and more. With the coronavirus likely disrupting supply chains, we note that CDN companies typically run their networks at lower utilization rates (<40%), and if the networks experience 1) increased demand or 2) supply chain impacts, running the networks “hotter” is margin accretive; we thus flag CDN providers as potential beneficiaries from the growing “work from home” trend.

Table 5: Video streaming to dominate global data consumption levels by 2024 (GB/month)

Traffic category	2018	2024
Downloads	0.6	1.2
Messaging	0.5	0.9
Application traffic	1	2.1
Audio streaming	0.1	0.4
Video streaming	3.4	16.3
Total	5.6	20.9

Source: Ericsson

Additionally, we note that the postponement of several sports seasons (such as the NBA and MLB) has several implications for CDN providers. On the one hand, the lack of live sporting events will hurt revenues, as there will be no streaming needs from the networks during peak hours. On the other hand, streaming highly popular live events typically inserts downward pressures on CDN margins due to discount pricing, so margins could tick slightly up.

We also believe that the market for Edge Cloud will benefit from workers moving to work remotely. We define the Edge Cloud market as the combination of the Content Delivery Network (CDN) market as well as the markets for specific application security solutions, including Web Application Firewall (WAF), Distributed Denial of Service (DDoS) mitigation, Bot detection, and more. At a high level, Edge Clouds provide real-time analytics and decrease latency by securely bringing data closer to the users, formatting applications/websites to load in real-time and be optimized for all devices, including handsets, tablets, PCs, etc.

Enterprise digital transformation is a key driver of the Edge Compute market, and COVID-19 is forcing the rapid digital transformation of many Enterprises in the US and abroad. As Enterprises shift from hosting their applications on-premise to public-cloud deployments, many Enterprises are utilizing multi-tenant architectures. We view the shift from working on-premise to working at home as positive for Edge Clouds providers such as Akamai and Fastly because workers will now have to access applications and data remotely, which will significantly increase Edge Cloud demand. We also note that pushing content to the edge of the network is less expensive than going back to large central clouds to access stored data, and expenses are top of mind for Enterprises amid office closures and lockdowns.

Data centers are real estate for work from home

Data center operators provide the infrastructure that supports telecommute, remote education and OTT solutions. We anticipate greater demand for data center capacity and connectivity as applications supporting these technologies are stressed by rising demand. Specifically, we anticipate greater demand at data center operators such as Equinix, which own and operate key network access points (NAPs) that can deliver lower latency and connectivity to support latency sensitive applications. Large wholesale providers, such as Digital Realty, are also well positioned as cloud providers increase hyper-scale capacity after a period of digestion.

Emergency/Mass notifications: Everbridge and Blackberry

Another technology that may now be more in focus is Crisis Communication for employees. Also referred to as Emergency or Mass Notifications, Crisis Communication platforms enable enterprises to notify employees and stakeholders with messages related to business continuity and safety. As the COVID-19 newsflow develops, we believe enterprise IT/HR teams must increasingly update the workforce. The platforms can also be used interactively so an employee can confirm the state of his/her safety and health. Location data can also be integrated to help employers can customize and prioritize message for workers in high-risk areas. As employees work remotely but remain closely tied with the business continuity process, the worker's location, health, and safety is imperative for organizations. According to a Gartner survey, only 37% of organizations had a full-use implementation of an Emergency/Mass Notification System in 2019.



We flag two leaders in the Crisis Communications market that could see some benefit. Everbridge is the market leader with what it dubs its Critical Event Management (CEM) Solutions that span employee safety, clinical response, IT alerts, and more. Blackberry's Athoc is a similar Crisis Communications suite that excels with mobile alerts and accountability. Athoc has a strong presence with government organizations and recently announced it was selected by Germany's Development Agency, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), as its emergency mass notification system. GIZ has over 20,000 employees and presence across more than 120 countries.

Table 6: Emergency/Mass Notification System leaders

Vendor	HQ	Ownership	Product/Platform
Agility Recovery	Denver, CO	Private	Preparis Portal
AlertMedia	Austin, TX	Private	AlertMedia — communications platform; SafeSignal — lone-worker safety application
Alertus Technologies	Beltsville, MD	Private	Alertus Unified Mass Notification System, Alert Beacon (in-building messaging), Alertus High-Powered Speakers (outdoor notification)
Assurance Software	Audubon, PA	Private	Assurance Notification Manager (Assurance NM)
Aurea	Austin, TX	Private	AlertFind
BlackBerry	San Mateo, CA	Public	BlackBerry AtHoc Networked Crisis Communication Suite (AtHoc Account, AtHoc Alert, AtHoc Connect, AtHoc Collect)
Everbridge	Burlington, MA	Public	Mass Notification, IT Services Alerting, Community Engagement, Safety Connection, Public Warning (UMS), Crisis Management
F24	Munich, Germany	Private	FACT24 basic, FACT24 professional, FACT24 premium, FACT24 ultimate PLUS
Motorola Solutions	Chicago, IL	Public	VESTA Communicator, VESTA Alert
Omnilert	Leesburg, VA	Private	Omnilert, Scenarios, Triggers
OnSolve	Ormond Beach, FL	Private	Send Word Now, MIR3, CodeRED, One Call Now, TelAlert
Rave Mobile Safety	Framingham, MA	Private	Rave Alert, Rave Guardian, Rave Panic Button, Rave Prepare, Rave 911 Suite, Rave Eyewitness, SwiftK12 and Smart911
Regroup	San Francisco, CA	Private	Regroup Mass Notification
Singlewire	Madison, WI	Private	InformaCast Fusion (Advanced and Mobile functionality on a single pane of glass — hybrid cloud), InformaCast Advanced (on-premises only), InformaCast Mobile (cloud only)
Volo	Ormond Beach, FL	Private	Volo Operations System (Volo OS) — Messenger, Virtual Switchboard, Virtual Bulletin Board, ThunderCall, Volo IQ, Site Manager
xMatters	San Ramon, CA	Private	xMatters Business Continuity Management

Source: Gartner, BofA Global Research

Semis picks: INTC, AMD, NVDA, AVGO, MRVL, IPHI

We also flag related semiconductor vendors impacted by the changing work/leisure routines. Both remote workers and consumers at home could drive a corresponding increase in processing and bandwidth requirements that would benefit our favored compute-levered semis: INTC, AMD, NVDA, AVGO, MRVL, and IPHI. From an enterprise/cloud perspective, AVGO cited on its EPS call last week the possibility that its networking semis business (40% of sales) could be more resilient on the back of stable-to-increasing hyperscale cloud spending to support greater than anticipated home data consumption. We also highlight recent positive data points from Hynix and Aspeed/Wywynn. From a consumer perspective, Steam – a popular online PC gaming platform – reported an all-time record for concurrent users within a single 24hr period this past weekend (20mn).

Internet: other things to do while at home

Video Games well positioned for work from home burnout

We believe video games and streaming media are among the best-positioned categories to weather the economic uncertainty caused by coronavirus as travel restrictions, quarantine, and/or limitations on events and activities should result in more time and money spent on Stay Home behavior. This view is more than anecdotal as recent data shows an inflection in several gaming trends that coincide with the first reports of patient deaths in the US, as well as severe preventative action taken in Europe. Specifically, data shows a sharp ~80% uplift in mobile gaming revenue trends in early March vs. mid-Feb, as well as a 5x uplift in Twitch streaming trends. Further, data also

shows total time-spent among the Top-10 most-popular PC games is up ~6% over the same period. We believe the overall uplift from Stay Home behavior will be beneficial to all publishers in the space and hesitate to call out one gaming stock in particular. However, ATVI and UBI have more new content launches and updates in 2020 relative to peers and should be relative out-performers.

Streaming benefits NFLX and adds to network usage

We see Netflix as one of the few businesses that could even see improving fundamentals from the outbreak. Mobile app download data from Japan, Korea, and Italy all validate this thesis and show improving y/y growth and sequential trends from 2/21, the date when the outbreak intensified in Korea and Italy. We also note Apptopia data showing that Netflix mobile app sessions in Korea are up almost 15% since Jan 1. We also note churn data from ANTENNA that shows improving churn trends in the US.

Supply Chain: CDW expertise in work from home solutions

As highlighted elsewhere in this note, customers have a range of solutions to choose from when it comes to OEM vendors for the software and hardware needed to implement work from home (WFH). However, not all customers have the technical capability to choose the right solution; in fact, the optimal solution may be a combination of products from multiple vendors.

This is where CDW, one of the largest US based technology Value Added Resellers (VAR) steps in. As a system integrator, CDW helps organizations assess, implement and adopt WFH solutions in the following areas:

- Endpoints: To provide access to the customer's applications and files from anywhere with Endpoints with VPN capability or Virtual Desktop solutions
- Collaboration: To enable collaboration with voice, video messaging and meetings
- Networking: To scale the customer's network capacity and connectivity infrastructure
- Security: To ensure that the customer's applications and data remain protected as it scales

The company has expertise working with multiple vendor products including those from Cisco, Citrix, Aruba, RingCentral, Palo Alto Networks, Fortinet, in addition to being a reseller for cloud services from Azure, Google Cloud Services and Amazon AWS (Fig 1).



Figure 1: CDW Work from home (WFH) services**Services**

Endpoint Solutions
Citrix: Citrix on Cloud or Citrix on-premises
VMware Horizon: on VMC on AWS or on-premises
Windows Virtual Desktop
Microsoft Teams Enterprise Chat and Share
Collaboration Solutions
Call, Message and Meet: Cisco, Microsoft, RingCentral
Contact Center: Cisco
Networking Solutions
Remote zero-touch provisioning access points: Cisco Meraki, Aruba
Network Assessment (capacity and remote access): Cisco, Meraki, Aruba
Security Solutions
VPN Configuration: Cisco, Palo Alto Networks, Fortinet
Identity and Access Management, Multifactor Authentication: Duo, Okta, Microsoft
Security Advisory Services: Authentication, Web Security, Endpoint
Cloud Application Security: Azure Sentinel, AWS
Flexible Service Plan
Technical Consulting: Ad hoc hours for staff augmentation in specific technology areas

Source: CDW

As an example which is relevant to what is happening today with COVID-19, CDW in the past implemented a WFH solution for a customer who needed to enable its doctors to work from home, keeping them free from any infections that may be ongoing in the hospital. CDW designed and implemented a secure telemedicine solution with MX68W Meraki Gateways with auto VPN back to the main hospital, so doctors would work from home.

In a typical engagement, CDW will work with the customer to identify the number of users the customer would like to enable to work remotely, then group the users into personas-based on application requirements, device type and collaboration needs. CDW can also implement solutions based on cloud (Microsoft Azure, Google GCP or Amazon AWS).

We reiterate our Buy on CDW (PO: \$150) as we expect the company to continue to outgrow the market. Pre-Covid19, the company had guided for revenues to grow 200-300bps above projected US IT market growth of 2.5-3.0% y/y in 2020. While growth would be slower including the impact of Covid19, we expect CDW to outperform its peers. A key competitive advantage remains CDW's deep customer relationships and experienced sales teams.

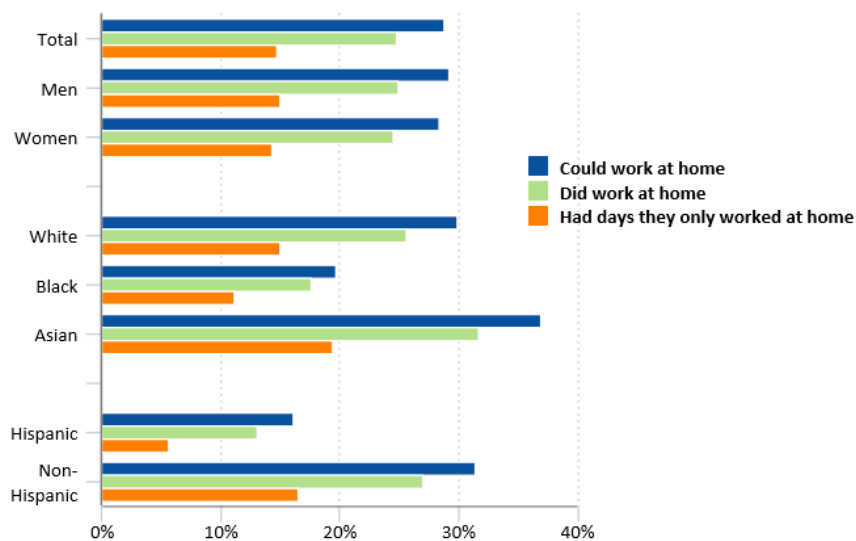
CDW has been resilient during past economic downturns. During the 2008-09 downturn, CDW revenues declined \$1bn, while GM declined ~150bps y/y, and EBITDA margins declined 80-90 bps. The business is more diversified today with more than a quarter of gross profit coming from netted-down items (including software and services). During economic downturns, customers tend to replace their assets less, and instead purchase more warranties and software assurance. So these netted down items can provide more support for gross profit during the next downturn.



CDW targets a dividend payout of 25% of net income. In the past the company has been able to generate strong free cash flow (FCF) and operates on a light capex model (typically 0.5% of sales), so servicing the dividend has not been an issue and we model dividends increasing annually

Appendix

Exhibit 7: BLS work from home survey results



Source: BLS

Table 7: BLS work from home and schedule flexibility survey results

Flexibility	Could work at home	Could not work at home
Had a flexible schedule	24%	33%
Did not have flexible schedule	38%	5%

Source: BLS



Table 8: US IT Spending by Vertical

	CY17	CY18	CY19	CY20	CY21	CY22	CY23	% of Total
Banking	128,576	136,749	143,661	151,909	160,057	168,593	177,415	12.5%
Securities	65,625	69,523	71,886	76,066	80,808	85,729	90,902	6.3%
Broadcasting and Cable	19,561	21,093	22,180	23,483	24,934	26,509	28,066	1.9%
Publishing and Advertising	8,877	9,345	9,744	10,407	11,056	11,684	12,314	0.9%
Telecommunications	48,802	52,596	55,786	59,340	63,013	66,877	70,781	4.9%
Entertainment	4,786	4,999	5,133	5,380	5,647	5,905	6,179	0.4%
Information Technology Services & Software	36,675	38,977	40,985	43,497	46,062	48,782	51,471	3.6%
Other Business, Technical and Consumer services	17,876	18,936	19,927	20,914	21,943	23,118	24,334	1.7%
Higher Education	14,583	15,356	15,972	16,829	17,714	18,637	19,586	1.4%
Primary and Secondary Education	10,931	11,495	11,945	12,577	13,196	13,814	14,359	1.0%
National & International Government	93,272	97,940	102,061	105,735	109,645	113,749	117,600	8.7%
Local & Regional Government	65,562	69,247	72,267	74,817	77,198	79,323	81,172	6.2%
Physician	7,168	7,662	8,092	8,591	9,111	9,656	10,168	0.7%
Hospital	35,880	38,188	40,000	42,180	44,349	46,584	48,797	3.5%
Health Insurance (payer)	20,731	21,967	22,962	24,043	24,998	26,007	26,964	2.0%
Insurance (other than health)	67,294	70,348	72,825	75,582	78,408	81,199	83,857	6.2%
IT Hardware	14,161	14,662	14,980	15,451	16,196	16,966	17,743	1.3%
Natural Resources & Materials	46,895	49,239	50,794	52,898	55,274	57,693	60,091	4.4%
Energy Resources & Processing	11,515	13,556	14,791	15,625	15,783	15,932	16,055	1.3%
Consumer Non-durable Products	28,650	29,203	29,256	29,593	31,216	32,907	34,631	2.4%
Automotive	20,517	22,069	23,422	24,743	25,485	26,232	26,956	2.0%
Life Sciences & Healthcare Products	17,496	18,573	19,528	20,629	21,385	22,153	22,911	1.7%
Heavy Industry	28,515	30,242	31,496	33,115	34,493	35,904	37,310	2.7%
General Retailers	13,722	14,540	15,260	15,935	16,633	17,321	18,004	1.3%
Grocery	12,400	12,951	13,433	14,193	14,990	15,794	16,609	1.2%
Restaurants and Hotels	19,885	21,222	22,282	23,258	24,267	25,261	26,245	1.9%
Specialty Retailers	48,186	51,109	53,633	56,011	58,472	60,896	63,297	4.6%
Air Transport	12,300	13,203	13,944	14,712	15,447	16,192	16,854	1.2%
Motor Freight	16,000	16,809	17,338	18,175	18,994	19,819	20,725	1.5%
Pipelines	1,456	1,534	1,589	1,661	1,724	1,811	1,881	0.1%
Rail and Water	8,505	9,039	9,415	9,940	10,462	11,011	11,415	0.8%
Warehousing, Couriers, Support Services	9,595	10,207	10,684	11,262	11,817	12,338	12,894	0.9%
Water Utilities	14,363	15,085	15,696	16,226	16,860	17,440	17,935	1.3%
Electric & Gas Utilities	43,028	45,677	47,625	49,798	51,889	54,014	56,276	4.1%
Wholesale Durable and Nondurable Goods	32,328	33,792	35,518	36,773	37,970	39,082	40,129	3.0%
Total US IT Spending	1,045,720	1,107,136	1,156,107	1,211,350	1,267,495	1,324,928	1,381,924	100.0%

Source: Gartner

Table 9: Global IT Spending by Vertical

	CY17	CY18	CY19	CY20	CY21	CY22	CY23	% of Total
Banking	398,725	420,065	444,539	469,420	493,327	518,247	543,463	13.4%
Securities	149,241	156,771	164,476	173,287	182,465	191,825	201,357	5.0%
Broadcasting and Cable	54,527	58,323	61,474	64,495	67,884	71,414	74,947	1.8%
Entertainment	18,816	19,673	20,581	21,329	22,171	23,051	23,976	0.6%
Information Technology Services & Software	117,774	124,343	130,853	136,423	142,567	149,061	155,753	3.9%
Other Business, Technical and Consumer services	67,832	71,254	74,697	77,350	80,358	83,550	86,833	2.2%
Publishing and Advertising	34,758	36,474	38,276	39,984	41,784	43,641	45,551	1.1%
Telecommunications	194,461	210,091	224,154	237,114	250,779	265,609	280,520	6.8%
Higher Education	42,474	44,554	46,634	48,980	51,095	53,318	55,603	1.4%
Primary and Secondary Education	29,384	30,763	32,146	33,693	35,201	36,704	38,191	1.0%
Local & Regional Government	189,918	198,734	207,193	214,626	221,283	227,759	234,229	6.1%
National & International Government	265,153	277,230	289,807	301,746	313,546	325,866	338,113	8.6%
Hospital	97,195	102,288	107,522	112,964	118,170	123,701	129,309	3.2%
Physician	19,963	21,067	22,111	23,137	24,245	25,372	26,526	0.7%
Health Insurance (payer)	37,754	39,922	41,865	43,769	45,473	47,247	48,993	1.3%
Insurance (other than health)	167,436	175,593	183,329	190,991	198,405	205,945	213,465	5.5%
Automotive	62,786	66,230	69,299	71,882	74,254	76,714	79,287	2.1%
Consumer Non-durable Products	94,940	98,109	100,996	104,093	109,164	114,481	120,135	3.0%
Energy Resources & Processing	31,271	35,623	38,760	40,892	41,451	42,066	42,744	1.2%
Heavy Industry	113,236	118,717	124,560	130,356	135,697	141,328	147,307	3.7%
IT Hardware	44,704	46,100	46,888	47,812	49,993	52,296	54,758	1.4%
Life Sciences & Healthcare Products	52,434	55,723	59,098	62,609	65,014	67,525	70,173	1.8%
Natural Resources & Materials	140,743	148,029	155,016	162,246	169,181	176,384	183,852	4.6%
General Retailers	36,378	38,399	40,338	42,097	43,852	45,636	47,554	1.2%
Grocery	33,843	35,464	37,045	38,971	40,850	42,773	44,847	1.1%
Restaurants and Hotels	33,747	35,926	37,854	39,523	41,109	42,701	44,362	1.1%
Specialty Retailers	100,931	106,834	112,342	117,268	122,132	127,079	132,293	3.4%
Air Transport	38,408	40,820	42,878	44,867	46,864	48,984	50,904	1.3%
Motor Freight	47,469	49,973	52,170	54,269	56,348	58,551	60,861	1.6%
Pipelines	3,868	4,050	4,224	4,371	4,508	4,687	4,851	0.1%
Rail and Water	28,147	29,643	31,260	32,634	33,960	35,376	36,740	0.9%
Warehousing, Couriers, Support Services	27,273	28,819	30,457	31,876	33,256	34,700	36,111	0.9%
Electric & Gas Utilities	125,197	132,236	138,392	144,471	149,980	155,603	161,739	4.1%
Water Utilities	31,338	32,899	34,323	35,606	36,875	38,133	39,347	1.0%
Wholesale Durable and Nondurable Goods	92,342	96,486	101,332	105,243	108,911	112,532	116,249	3.0%
Total Global IT Spending	3,024,465	3,187,223	3,346,891	3,500,393	3,652,150	3,809,859	3,970,943	100.0%

Source: Gartner

Stocks mentioned

BofA Ticker	Bloomberg ticker	Company name	Price	Rating
AMD	AMD US	Advanced Micro	US\$ 39.61	C-1-9
BB	BB US	BlackBerry	US\$ 3.38	B-2-9
AVGO	AVGO US	Broadcom	US\$ 192.22	B-1-7
CDW	CDW US	CDW	US\$ 79.56	B-1-7
CSCO	CSCO US	Cisco Systems	US\$ 35.6	B-2-7
CTXS	CTXS US	Citrix	US\$ 119.33	B-2-9
CRWD	CRWD US	CrowdStrike	US\$ 49.01	C-1-9
DLR	DLR US	Digital Realty Trust	US\$ 121.2	B-1-7
EQIX	EQIX US	Equinix	US\$ 506.52	B-1-7
EVBG	EVBG US	Everbridge	US\$ 100.27	B-1-9
FSLY	FSLY US	Fastly	US\$ 17.71	C-1-9
IPHI	IPHI US	Inphi	US\$ 58.59	C-1-9
INTC	INTC US	Intel	US\$ 45.83	B-1-7
MRVL	MRVL US	Marvell	US\$ 18.67	B-1-7
NFLX	NFLX US	Netflix	US\$ 332.83	B-1-9
NVDA	NVDA US	Nvidia	US\$ 205.75	C-1-7
PANW	PANW US	Palo Alto Networks	US\$ 143.53	B-2-9
PING	PING US	Ping Identity	US\$ 18.25	C-1-9
RNG	RNG US	RingCentral, Inc	US\$ 183.86	B-1-9
VMW	VMW US	VMware Inc	US\$ 105.72	B-1-9
ZM	ZM US	Zoom	US\$ 130.55	C-1-9
ZS	ZS US	Zscaler	US\$ 53.64	C-1-9

Source: BofA Global Research



Price objective basis & risk

Advanced Micro Devices, Inc (AMD)

Our \$53 price objective (PO) is based on 38x 2021E pro-forma PE, which is in line with potential EPS growth from CY19-23E in a bull case scenario, and well supported by AMD's ability to take share in large markets.

Downside risks: 1) Sharp correction in share price following strong rally to-date, 2) Strong competition from larger names, 3) Lumpy nature of consumer and enterprise spending that could create delays in acceptance and success of new products, 4) Reliance on multiple outsourced manufacturing partners, 5) Maturity of current game console cycle.

BlackBerry (BB)

Our \$6 PO is based on roughly 2.5x EV/S on our CY21E software sales. This multiple is roughly in line with other low growth/challenged software/services companies and supported by our sum-of-parts valuation.

Downside risks to our PO are: 1) Slowdown in smartphone or enterprise software market due to macroeconomic weakness, 2) Margin pressure from SAF decline and low software growth, 3) Competitive risks from Apple, Google (Android), Samsung, VMware, Microsoft, and more, 4) Increased investment required to support new products, and 5) Security breach and reputational risk.

Upside risks to our price objective are: 1) Success of new product launches, 2) Restructuring efforts, asset sales, or transformative M&A, 3) large unexpected IP deals.

Broadcom Inc (AVGO)

Our \$255 price objective for Broadcom is based on 14x CY21E EV/FCF, lower end of large-cap peer group range of 13x-24x to reflect the overhang around Broadcom's software M&A strategy which dilutes its semiconductor sales growth potential.

Downside risks to our price objective are: 1) Semiconductor cycle risks including sensitivity to US/China trade relations, 2) High exposure to Apple with potential design out risks, 3) Competitive risks in networking, smartphone, storage, enterprise software markets, 4) Frequent acquirer of assets which increases financial and integration risks, and 5) Recent strategy towards moving into non-core software businesses creates mis-execution risks.

CDW Corp (CDW)

Our PO of \$150 is based on 22x C20 EPS of \$6.71. Our target multiple is towards the high end of the historical range (12x to 24x, with median 16x). We believe a high multiple is justified given the consistent out execution vs. competitors and EPS expectations, as well as the best in class margin profile for the IT distribution segment. CDW has broken out of its traditional median multiple since the beginning of C2017.

Downside risks to our price objective are: (1) heavy exposure to hardware at 80% of revenues, (2) continual shift of infrastructure to the public cloud, (3) highly price competitive nature of the IT distribution & reseller industry, (4) key vendor risk as top 7 vendors make up 60% of revenues, and (5) slowdown of U.S. IT spending

Cisco Systems (CSCO)

Our \$47 PO is based primarily on 12x EV/FCF multiple using our CY2021 estimate, in-line with tech peers at 11-12x (appropriate given Cisco's stability and high 3.0% dividend yield) but a slight discount to industrial peers (roughly 18-20x) given a modestly lower growth profile and market-specific risks. We also focus on FCF to better capture software rev growth and shift to subscription models.



Downside risks to our price objective are: (1) deterioration in the spending environment, (2) lack of growth in public spending, a vertical that Cisco dominates, (3) downside risk to gross margin stemming from pricing and competitive pressures, (4) technological changes that would adversely impact high profit switching and routing segments, (5) inability to drive technological innovation in its core and new growth segments, and (6) change in customer behavior that would result in revenue pressure in services and other key areas.

Upside risks to our price objective are: (1) strong growth in new markets like NFV and SDN, (2) higher than expected growth in key markets, particularly switching and routing, and (3) solid market share gains in security and collaboration.

Citrix Systems Inc (CTXS)

Our \$140 PO is based on 17.8x 2021E FCF, 10% below software infrastructure comps VMware, Microsoft, Oracle, given cloud transition uncertainty.

Upside risks to our PO are: multiple revenue levers in both WorkSpace and Networking causing the revenue growth rate to accelerate, faster than expected margin improvement, M&A.

Downside risks to our PO are: worsening macro environment, increase in competition, ability to execute on the restructuring plan, bigger than expected disruption from the restructuring plan.

CrowdStrike Holdings Inc. (CRWD)

Our PO of \$75 is based on roughly 17x our CY21E EV/Sales. We choose EV/Sales as our target valuation metric due to CrowdStrike's early growth stage and investment period creating outsized operating losses in the near term. The multiple is a premium versus SaaS-based software companies (10x) and versus SaaS/cyber security peers (15x). We believe a premium valuation is warranted due to CrowdStrike's higher growth profile and potential to take meaningful share in new markets that would increase TAM and potentially accelerate growth. The positives of CrowdStrike's high growth and long-term opportunities are somewhat offset by lower margins.

Upside risks to our PO are: 1) faster-than expected adoption of CrowdStrike's new cloud modules and 2) a faster displacement of legacy players with next-gen, cloud-native architectures.

Downside risks to our PO are: 1) investor sentiment and sensitivity to the premium valuation levels, 2) a lower take-rate of new offerings, 3) material slowdown in new customer adoption and expansion deals, 4) risk of security breaches, and 5) an increase in competition from incumbent vendors and newer next-gen players.

Digital Realty Trust Inc (DLR)

Our PO of \$140 is based on a target AFFO multiple of 21x 2019E. This is a premium to the data center REIT average reflecting Digital Realty's premium global data center portfolio and improving growth profile. We now project a 50bp Y/Y improvement in AFFO/share growth in 2019 as DLR experiences the full year benefit of strong signings YTD and less dilution from recent financing activity. We also believe the stock warrants a premium multiple insofar as REIT investors are incremental buyers of data center stocks. Digital Realty is most likely to benefit based on its portfolio of owned assets, investment grade balance sheet, market cap and liquidity.

Downside risks to our price objective are increased competition, customer consolidation or bankruptcies. As a real estate company, Digital Realty remains exposed to excessive



new supply in its markets, rising construction and capital costs, real estate values, and rising interest rates.

Equinix, Inc. (EQIX)

Our \$700 price objective is based on a target multiple of 25x 2020E AFFO/share. Our target multiple is above the average target multiple for our data center REIT coverage universe, reasonable, in our view, considering growth, solid underlying fundamental business drivers, low macro sensitivity and positive exposure to technology trends

The risks to our price objective are: 1) a prolonged downturn in Enterprise IT spending, 2) meaningful exposure to the financial industry, and 3) fluctuating FX rates.

Everbridge (EVBG)

Our PO of \$130 is based on an EV/sales multiple of 15.7x our C21 revenue estimate, a premium to the SaaS group (8x) given a long runway of 30%+ growth for Everbridge.

Downside risks are: 1) lower than expected revenue growth/market share gains resulting from new competition arising due to low barriers to entry in EMNS market, 2) lower than expected revenue growth due to price erosion from low usage of product, 3) pullback to the stock's multiple more than expected due to slowdown in macro sentiment or disappointing results given EVBG is an earlier stage company with higher degree of execution risk.

Fastly (FSLY)

Our PO of \$22 is based on roughly 6x FY21E EV/Sales. We note this multiple represents a steep premium to other Content Delivery Networking (CDN) and Networking Services peers who trade at 3x CY21 EV/Sales, yet Fastly is expected to grow roughly 30% per annum, while Street consensus calls for 6-8% annual growth for CDN peers Akamai and Limelight. We compare Fastly instead to SaaS peers that have a similar growth profile, and to infrastructure software peers Twilio, New Relic and MongoDB, who also have similar growth expectations (by consensus estimates) and who, like Fastly, expect to grow revenues in-line with their customers' levels of activity. We apply some discount to the former group given Fastly's lower margin structure.

Upside risks to our PO are: 1) higher growth rates on greater adoption of Fastly's platform 2) broad adoption of Fastly's Security and Edge Compute offerings, and 3) margin uplift from bandwidth and colocation costs scaling sooner than expected.

Downside risks to our PO are: 1) lower margin ramp and push outs in time to profitability, 2) more intense competition from Cloud titans like Google and Amazon, and 3) price erosion from the commoditization of basic CDN features.

Inphi Corporation (IPHI)

Our PO of \$95 is based on 30x 2021E PE, a premium to the peer median (15x), but justified in our view given our projection for IPHI's superior long-term EPS growth rate.

Downside risks to our PO are: 1) lumpy capex by key cloud and telco customers, 2) macro especially China related headwinds impacting metro and data center-related spending and impact from tariffs, 3) competition from direct merchant and indirect vertically-integrated competitors in metro and data center impacting growth expectations, 4) Gross margins pressure from mix shift to data center, and 5) premium PE multiple vs. other semis makes stock very sensitive to any potential execution errors or weakness in the demand environment.

Intel (INTC)

Our \$60 price objective is based on 17x EV/FCF our 2021 estimate, more in line with diversified peers, which we view as appropriate given our outlook for strong consistent FCF growth relative to peers.

Downside risks to our price objective are: 1) Any weaker-than-expected trends in a mature PC market, which is largest revenue generator for Intel, 2) Competition in profitable data center market, 3) Increasing cost and complexity of semiconductor manufacturing that pressures capex and gross margins, 4) Semiconductor and macro cycle risks, and 5) Financial/integration risks in any M&A.

Marvell Technology Group Ltd. (MRVL)

Our \$26 PO is based on a 22x FY22E/CY21E pf-EPS, inline with the nearly 30% longer-term compounded annual EPS growth potential, driven by potential success in 5G over the next few years. This multiple is also inline with other SMidcap semiconductor growth peers at early stages of new product cycles.

Downside risks: 1) Integration risks in recent deals, 2) Financial risks related to going to net debt from net cash position, and in achieving expected cost synergies in a timely manner, and 3) Cyclical industry risks including potential slowdown in legacy hard disk drive and storage assets, 4) Competitive risks against larger well resourced rivals such as AVGO, INTC and NVDA.

Netflix, Inc. (NFLX)

Our \$426 price objective is based on a peak penetration sum-of-the-parts analysis which discounts back future EPS at peak penetration by 10%. At peak penetration, we assume US & Canada streams peak at 77.5mn subscribers in four years while the rest of world reaches 300mn within twelve years. We assume 40% contribution margin for both the domestic and international businesses. We assume a US tax rate of 25% and an international tax rate of 22%. At peak penetration, we assume a 17x S&P500 average multiple.

Downside risks to our price objective are: 1) increasing content costs, 2) new competitors in the company's streaming business, 3) execution challenges and competition potentially limiting growth in new markets, 4) U.S. saturation point approaching more quickly than expected, and 5) net neutrality repeal causing ISPs to look to recoup higher rents from Netflix's high bandwidth requirements for streaming.

Upside risks to our price objective are: 1) content costs rising more slowly than expected, 2) total subscriber growth is faster than expected, and 3) international expansion into new large markets (e.g. China).

NVIDIA Corporation (NVDA)

Our \$300 PO is based on 33x CY21E PE ex cash which is a premium to the sector (15x) and reflects Nvidia's superior long-term growth profile in large, underpenetrated markets. Our choice of multiple is in between NVDA's historical 20x-45x PE range.

Risks to our price objective are: 1) exposure to PC market, 2) Competition with INTC & PLD companies in HPC/accelerated computing markets and MCU vendors in Autos. 3) Lumpy and unpredictable sales in new enterprise, data center, and autos markets, 4) Potential for decelerating capital returns, 5) potential for autos slowdown until ADAS becomes more meaningful, and 6) elevated opex growth.

Palo Alto Networks (PANW)

Our price objective of \$200 is based on roughly 4.5x CY21E EV/Sales, which is mostly in line with the average group multiple of similar fast-growth SaaS and software companies, which trade at roughly 4-6x our 2021E EV/Sales. We believe a similar market multiple is warranted, given the ongoing shift to subscription software, slightly offset with Palo Alto's hardware exposure and recent sales departures.



Downside risks to our PO are: 1) Increased competition stemming from new comparable products launched by competitors, such as Cisco, Check Point, SonicWALL (Dell) and Fortinet, and 2) potential for execution-related challenges or cloud transition challenges.

Ping Identity (PING)

Our PO of \$27 is based on roughly 7x CY21E EV/Sales. We choose EV/Sales as our target valuation metric due to Ping's strategy to increase investments and maintain high revenue growth rates as it captures an attractive market opportunity. The multiple is at the lower end of high-growth subscription software peers at 7-10x, and cyber security peers at 7-17x. We view Ping as close peers with identity vendors such as Okta and CyberArk. Ping's lower growth profile and lower SaaS exposure warrant a discount to Okta's 15x but the subscription model and large TAM drive our view that Ping should trade more in-line with CyberArk at roughly 6x. Over time, if Ping can reaccelerate revenue growth and shift more to cloud-based identity, Ping's model would become more in-line with close peer Okta, in our view.

Upside risks to our PO are: 1) large deals that are recognized in period may drive up revenue growth and are difficult to forecast, 2) faster than expected upsell of newer software offerings like multi-factor authentication and Directory, and 3) a significant shift in spending toward Identity solutions across workforce, consumer, and IoT use cases. Downside risks to our PO are: 1) slower than expected development of Ping's cloud platform, 2) lower than expected revenue growth due to timing of large deals, 3) competitive threats from larger competitors or cloud-focused newcomers, and 4) significant customer loss due to rapid shift away from on-premise IT environments.

RingCentral, Inc (RNG)

Our \$215 PO is based on 14x CY21E EV/revs, a premium to the comps to account for meaningful long-term economic value creation from the Avaya and AT&T partnerships. The company has the largest scale among cloud-based pure-play vendors and the potential for market disruption.

Downside risks to our PO are: 1) benefits of the Avaya partnership take longer than expected, 2) changes in strategic direction, 3) failure to scale upmarket, 4) higher-than-anticipated customer support and acquisition costs as the company scales up market, 5) macro economy negatively affecting the company's SMB-centric customer base, and 6) competition including Skype for Business and Zoom Phone.

VMware Inc (VMW)

Our \$120 PO of VMW is based on 12.4x CY21E EV/FCF multiple, a 25% discount vs comparable growth peers such as MSFT, and SAP, due to the SaaS transition impacting near-term revenue growth and potentially margins and to account for M&A execution risk.

Risks to our price objective are a worsening macro, increased share by public clouds, and increased competition.

Zoom Video Communications Inc (ZM)

Our PO of \$140 is based on 64x EV/FCF multiple on FY26E FCF, adding net cash and discounting back at 10% to FY20E. Our choice of 64x EV/FCF multiple is in-line with established software companies when they had reached \$1bn in revenue, as Zoom's continued strong growth rate depends on its execution and success in adjacent markets.

Our PO implies a 32x multiple on CY21E revenue, a premium to the broader SaaS group trading at 10x. We believe a premium multiple is justified given: 1) market leadership in video conferencing with a strong technological moat, and 2) best in class sales efficiency model supporting strong margin leverage in the long run.

Downside risks are macroeconomic downturn, ability to capture share in broader UCaaS market (non-video), high competition, and US-China trade war poses some risk as a majority of engineers are based in China and under high protectionism the company may have to increase R&D spending to hire locally.

Zscaler (ZS)

Our PO of \$65 is based on roughly 14x CY21E EV/Sales. We choose EV/Sales as our target valuation metric due to Zscaler's early growth stage and investment period creating pressure on operating margins in the near term. The multiple is a premium versus high-growth security peers (5-7x) and a premium to high-growth software peers (8-13x), but more in-line with high growth SaaS security peers at 10-15x. We believe a premium is warranted due to Zscaler's higher growth profile and potential to take meaningful share in new markets that would increase the TAM and potentially accelerate growth. The positives of Zscaler's high growth and longer-term opportunities balance the risk related to the current valuation premium, in our view.

Upside risks to our PO are: 1) faster-than-expected adoption of Zscaler's new products, such as Zscaler Private Access, 2) higher ASP uplift due to adoption of high-end offerings like the Cloud Next-generation firewall and Cloud Sandbox, and 3) a more significant shift to cloud-based security across enterprises of all sizes. Downside risks to our PO are: 1) a lower take-rate of new offerings, 2) material slowdown in new customer adoption and expansion deals, 3) risk of network outages or security breaches, and 4) an increase in competition from incumbent vendors and newer start-ups.

Analyst Certification

We, Tal Liani, Brad Sills, Daniel Bartus, David W. Barden, CFA, Jessica Reif Ehrlich, Justin Post, Kash Rangan, Michael J. Funk, Nat Schindler, Nikolay Beliov, CFA, Ruplu Bhattacharya and Vivek Arya, hereby certify that the views each of us has expressed in this research report accurately reflect each of our respective personal views about the subject securities and issuers. We also certify that no part of our respective compensation was, is, or will be, directly or indirectly, related to the specific recommendations or view expressed in this research report.



US - Enterprise Software Coverage Cluster

Investment rating	Company	BofA Ticker	Bloomberg symbol	Analyst
BUY				
	Adobe	ADBE	ADBE US	Kash Rangan
	Alarm.com	ALRM	ALRM US	Nikolay Beliov, CFA
	Alteryx, Inc	AYX	AYX US	Brad Sills
	Atlassian Corporation Plc	TEAM	TEAM US	Nikolay Beliov, CFA
	Avalara Inc	AVLR	AVLR US	Brad Sills
	Bill.com, Inc.	BILL	BILL US	Brad Sills
	Cornerstone OnDemand, Inc.	CSOD	CSOD US	Brad Sills
	Coupa Software Inc	COUP	COUP US	Brad Sills
	Elastic N.V.	ESTC	ESTC US	Kash Rangan
	Everbridge	EVBG	EVBG US	Brad Sills
	Intuit	INTU	INTU US	Kash Rangan
	Medallia	MDLA	MDLA US	Kash Rangan
	Microsoft Corp	MSFT	MSFT US	Kash Rangan
	RingCentral, Inc	RNG	RNG US	Nikolay Beliov, CFA
	Salesforce.com	CRM	CRM US	Kash Rangan
	ServiceNow, Inc.	NOW	NOW US	Kash Rangan
	Splunk Inc.	SPLK	SPLK US	Kash Rangan
	SurveyMonkey, Inc	SVMK	SVMK US	Brad Sills
	Twilio Inc	TWLO	TWLO US	Nikolay Beliov, CFA
	Veeva Systems, Inc.	VEEV	VEEV US	Brad Sills
	VMware Inc	VMW	VMW US	Kash Rangan
	Workday	WDAY	WDAY US	Kash Rangan
	Zendesk, Inc.	ZEN	ZEN US	Brad Sills
	Zoom Video Communications Inc	ZM	ZM US	Nikolay Beliov, CFA
NEUTRAL				
	Citrix Systems Inc	CTXS	CTXS US	Nikolay Beliov, CFA
	DocuSign, Inc.	DOCU	DOCU US	Kash Rangan
	Guidewire Software, Inc.	GWRE	GWRE US	Brad Sills
	Oracle	ORCL	ORCL US	Kash Rangan
	Pluralsight Inc	PS	PS US	Brad Sills
UNDERPERFORM				
	8x8, Inc.	EGHT	EGHT US	Nikolay Beliov, CFA
	Autodesk	ADSK	ADSK US	Kash Rangan
	Blackbaud, Inc.	BLKB	BLKB US	Brad Sills
	Cloudera	CLDR	CLDR US	Kash Rangan
	Five9, Inc	FIVN	FIVN US	Nikolay Beliov, CFA
	Norton LifeLock	NLOK	NLOK US	Nikolay Beliov, CFA
	Shopify, Inc.	SHOP	SHOP US	Brad Sills
	Solarwinds Corp	SWI	SWI US	Kash Rangan

US - Internet Coverage Cluster

Investment rating	Company	BofA Ticker	Bloomberg symbol	Analyst
BUY				
	Activision	ATVI	ATVI US	Ryan Gee
	Alphabet	GOOGL	GOOGL US	Justin Post
	Alphabet	GOOG	GOOG US	Justin Post
	Amazon.com	AMZN	AMZN US	Justin Post
	Cardlytics	CDLX	CDLX US	Nat Schindler
	Carvana Co	CVNA	CVNA US	Nat Schindler
	Chewy Inc	CHWY	CHWY US	Nat Schindler
	Dropbox	DBX	DBX US	Justin Post
	Facebook	FB	FB US	Justin Post
	Fiverr	FVRR	FVRR US	Nat Schindler
	IAC InterActive	IAC	IAC US	Nat Schindler
	LendingTree	TREE	TREE US	Nat Schindler
	Match Group	MTCH	MTCH US	Nat Schindler
	Netflix, Inc.	NFLX	NFLX US	Nat Schindler
	Peloton	PTON	PTON US	Justin Post
	Snap	SNAP	SNAP US	Justin Post
	Take-Two Interactive	TTWO	TTWO US	Ryan Gee
	Twitter	TWTR	TWTR US	Justin Post
	Uber	UBER	UBER US	Justin Post
	Ubisoft	UBSFF	UBI FP	Ryan Gee
	Wix.com	WIX	WIX US	Nat Schindler
NEUTRAL				
	Booking Holdings Inc	BKNG	BKNG US	Justin Post
	eBay	EBAY	EBAY US	Justin Post
	Electronic Arts	EA	EA US	Ryan Gee
	Everquote	EVER	EVER US	Nat Schindler
	Expedia	EXPE	EXPE US	Justin Post
	Pinterest	PINS	PINS US	Justin Post
	Redfin Corp	RDFN	RDFN US	Nat Schindler
	Revolve	RVLV	RVLV US	Justin Post
	The RealReal	REAL	REAL US	Justin Post
	Wayfair	W	W US	Justin Post
	ZYNGA	ZNGA	ZNGA US	Ryan Gee
UNDERPERFORM				
	Arlo Technologies Inc	ARLO	ARLO US	Nat Schindler
	GrubHub	GRUB	GRUB US	Nat Schindler
	Quotient Technology Inc	QUOT	QUOT US	Nat Schindler
	SciPlay	SCPL	SCPL US	Ryan Gee
	TripAdvisor	TRIP	TRIP US	Nat Schindler
	Trivago NV	TRVG	TRVG US	Nat Schindler
	Zillow	ZG	ZG US	Nat Schindler
	Zillow	Z	Z US	Nat Schindler



US - REITs Coverage Cluster

Investment rating	Company	BofA Ticker	Bloomberg symbol	Analyst
BUY				
	Acadia Realty Trust	AKR	AKR US	Craig Schmidt
	Alexandria Real Estate Equities	ARE	ARE US	James Feldman
	American Campus Communities, Inc.	ACC	ACC US	Jeffrey Spector
	American Homes 4 Rent	AMH	AMH US	Jeffrey Spector
	Armada Hoffer Properties	AHH	AHH US	James Feldman
	Boston Properties	BXP	BXP US	Jeffrey Spector
	Brixmor Property Group	BRX	BRX US	Craig Schmidt
	Cousins Properties Inc.	CUZ	CUZ US	James Feldman
	CYRUSONE INC	CONE	CONE US	Michael J. Funk
	Digital Realty Trust Inc	DLR	DLR US	Michael J. Funk
	EastGroup Properties	EGP	EGP US	James Feldman
	Equity Commonwealth	EQC	EQC US	James Feldman
	Equity LifeStyle Properties	ELS	ELS US	Jeffrey Spector
	Equity Residential	EQR	EQR US	Jeffrey Spector
	Essential Properties	EPRT	EPRT US	Joshua Dennerlein
	Essex Property Trust, Inc.	ESS	ESS US	Jeffrey Spector
	Extra Space Storage, Inc.	EXR	EXR US	Jeffrey Spector
	Federal Realty	FRT	FRT US	Jeffrey Spector
	Getty Realty Corp.	GTY	GTY US	Joshua Dennerlein
	Healthpeak Properties, Inc.	PEAK	PEAK US	Joshua Dennerlein
	Highwoods Properties	HIW	HIW US	James Feldman
	Hudson Pacific Properties, Inc.	HPP	HPP US	James Feldman
	Invitation Homes Inc	INVH	INVH US	Jeffrey Spector
	Kilroy Realty Corporation	KRC	KRC US	James Feldman
	Kimco Realty	KIM	KIM US	Craig Schmidt
	National Retail Properties	NNN	NNN US	Joshua Dennerlein
	OMEGA Healthcare	OHI	OHI US	Joshua Dennerlein
	Prologis, Inc.	PLD	PLD US	James Feldman
	QTS Realty Trust Inc	QTS	QTS US	Michael J. Funk
	Realty Income	O	O US	Jeffrey Spector
	Regency	REG	REG US	Craig Schmidt
	Rexford Industrial Realty	REXR	REXR US	James Feldman
	Simon Property	SPG	SPG US	Jeffrey Spector
	SL Green Realty	SLG	SLG US	James Feldman
	Sun Communities	SUI	SUI US	Joshua Dennerlein
	UDR, Inc.	UDR	UDR US	Jeffrey Spector
	VEREIT	VER	VER US	Joshua Dennerlein
	Weingarten Rlty	WRI	WRI US	Craig Schmidt
NEUTRAL				
	Americold Realty Trust	COLD	COLD US	Joshua Dennerlein
	Apartment Investment and Management Co.	AIV	AIV US	Jeffrey Spector
	AvalonBay Communities Inc	AVB	AVB US	Jeffrey Spector
	Camden Property Trust	CPT	CPT US	Jeffrey Spector
	Corporate Office Properties Trust	OFC	OFC US	James Feldman
	Douglas Emmett	DEI	DEI US	James Feldman
	Duke Realty	DRE	DRE US	James Feldman
	Empire State Realty Trust	ESRT	ESRT US	James Feldman
	JBG Smith Properties	JBGS	JBGS US	James Feldman
	Kennedy Wilson	KW	KW US	James Feldman
	Kite Realty Group	KRG	KRG US	Craig Schmidt
	Life Storage Inc.	LSI	LSI US	Jeffrey Spector
	Macerich	MAC	MAC US	Jeffrey Spector
	Medical Properties Trust, Inc.	MPW	MPW US	Joshua Dennerlein
	Paramount Group	PGRE	PGRE US	James Feldman
	Physicians Realty Trust	DOC	DOC US	Joshua Dennerlein
	Public Storage, Inc.	PSA	PSA US	Jeffrey Spector
	Sabra Health Care	SBRA	SBRA US	Joshua Dennerlein
	Spirit Realty Capital	SRC	SRC US	Joshua Dennerlein
	Tanger Factory	SKT	SKT US	Craig Schmidt
	Ventas, Inc.	VTR	VTR US	Jeffrey Spector
	Vornado Realty	VNO	VNO US	James Feldman
	Welltower	WELL	WELL US	Joshua Dennerlein
UNDERPERFORM				
	American Assets Trust	AAT	AAT US	Craig Schmidt



US - REITs Coverage Cluster

Investment rating	Company	BofA Ticker	Bloomberg symbol	Analyst
	Brandywine Realty	BDN	BDN US	James Feldman
	Coresite Realty Corp	COR	COR US	Michael J. Funk
	CubeSmart	CUBE	CUBE US	Jeffrey Spector
	Diversified Healthcare Trust	DHC	DHC US	Joshua Dennerlein
	EPR Properties	EPR	EPR US	Joshua Dennerlein
	Industrial Logistics Properties Trust	ILPT	ILPT US	James Feldman
	Iron Mountain	IRM	IRM US	Michael J. Funk
	Lexington Realty Trust	LXP	LXP US	James Feldman
	Mack-Cali Realty	CLI	CLI US	James Feldman
	Office Properties Income Trust	OPI	OPI US	James Feldman
	Retail Opportunity Investments Corp.	ROIC	ROIC US	Craig Schmidt
	RPT Realty	RPT	RPT US	Craig Schmidt
	STAG Industrial	STAG	STAG US	James Feldman
	WP Carey	WPC	WPC US	Joshua Dennerlein
RSTR				
	Taubman Centers	TCO	TCO US	Craig Schmidt

North America - Telecom Services Coverage Cluster

Investment rating	Company	BofA Ticker	Bloomberg symbol	Analyst
BUY				
	American Tower Corp.	AMT	AMT US	David W. Barden, CFA
	AT&T Inc.	T	T US	David W. Barden, CFA
	BCE Inc.	YBCE	BCE CN	David W. Barden, CFA
	BCE Inc.	BCE	BCE US	David W. Barden, CFA
	CBRE Group	CBRE	CBRE US	Michael J. Funk
	Cogeco Communications Inc.	YCCA	CCA CN	Matthew Griffiths, CFA
	Crown Castle International Corp.	CCI	CCI US	David W. Barden, CFA
	Dish Network Corporation	DISH	DISH US	David W. Barden, CFA
	Equinix, Inc.	EQIX	EQIX US	Michael J. Funk
	Newmark Group	NMRK	NMRK US	Michael J. Funk
	Rogers Communications	RCI	RCI US	David W. Barden, CFA
	Rogers Communications	YRCIB	RCI/B CN	David W. Barden, CFA
	SBA Communications Corporation	SBAC	SBAC US	David W. Barden, CFA
	TELUS Corporation	YT	T CN	David W. Barden, CFA
	TELUS Corporation	TU	TU US	David W. Barden, CFA
	Verizon Communications Inc.	VZ	VZ US	David W. Barden, CFA
NEUTRAL				
	Cushman & Wakefield	CWK	CWK US	Michael J. Funk
	Jones Lang LaSalle Incorporated	JLL	JLL US	Michael J. Funk
	Quebecor Inc.	YQBRB	QBR/B CN	Matthew Griffiths, CFA
	Shaw Communications Inc	SJR	SJR US	David W. Barden, CFA
	Shaw Communications Inc	YSJRB	SJR/B CN	David W. Barden, CFA
UNDERPERFORM				
	CenturyLink	CTL	CTL US	David W. Barden, CFA
	Cogent	CCOI	CCOI US	Michael J. Funk
	Frontier Communications Corp.	FTR	FTR US	David W. Barden, CFA
RVW				
	Uniti Group Inc	UNIT	UNIT US	David W. Barden, CFA



US - Telecom and Data Networking Equipment Coverage Cluster

Investment rating	Company	BofA Ticker	Bloomberg symbol	Analyst
BUY				
	Allot Communications	ALLT	ALLT US	Tal Liani
	Amdocs	DOX	DOX US	Tal Liani
	CommScope	COMM	COMM US	Tal Liani
	CrowdStrike Holdings Inc.	CRWD	CRWD US	Tal Liani
	CyberArk	CYBR	CYBR US	Daniel Bartus
	Ericsson	ERIXF	ERICB SS	Tal Liani
	Ericsson	ERIC	ERIC US	Tal Liani
	Fastly	FSLY	FSLY US	Tal Liani
	Fortinet	FTNT	FTNT US	Tal Liani
	Mimecast	MIME	MIME US	Daniel Bartus
	Nokia	NOKBF	NOKIA FH	Tal Liani
	Nokia	NOK	NOK US	Tal Liani
	Ping Identity	PING	PING US	Tal Liani
	Proofpoint	PFPT	PFPT US	Daniel Bartus
	Qualcomm	QCOM	QCOM US	Tal Liani
	Zscaler	ZS	ZS US	Daniel Bartus
NEUTRAL				
	Arista Networks	ANET	ANET US	Tal Liani
	BlackBerry	BB	BB US	Daniel Bartus
	CIENA	CIEN	CIEN US	Tal Liani
	Cisco Systems	CSCO	CSCO US	Tal Liani
	FireEye Inc.	FEYE	FEYE US	Tal Liani
	Palo Alto Networks	PANW	PANW US	Tal Liani
UNDERPERFORM				
	Check Point Software Technologies	CHKP	CHKP US	Tal Liani
	F5 Networks	FFIV	FFIV US	Tal Liani
	Juniper Networks	JNPR	JNPR US	Tal Liani
	SecureWorks	SCWX	SCWX US	Tal Liani
	Ubiquiti	UI	UI US	Tal Liani

US - IT Hardware and Technology Supply Chain Coverage Cluster

Investment rating	Company	BofA Ticker	Bloomberg symbol	Analyst
BUY				
	Amphenol	APH	APH US	Wamsi Mohan
	Apple Inc.	AAPL	AAPL US	Wamsi Mohan
	CDW Corp	CDW	CDW US	Ruplu Bhattacharya
	Corning Inc.	GLW	GLW US	Wamsi Mohan
	Dell Technologies Inc.	DELL	DELL US	Wamsi Mohan
	Flex Ltd.	FLEX	FLEX US	Ruplu Bhattacharya
	Hewlett-Packard Enterprise	HPE	HPE US	Wamsi Mohan
	International Business Machines Corp.	IBM	IBM US	Wamsi Mohan
	Nutanix Inc	NTNX	NTNX US	Wamsi Mohan
	Pure Storage	PSTG	PSTG US	Wamsi Mohan
	Roku, Inc.	ROKU	ROKU US	Ziv Israel
	Sensata Technologies Holdings Plc	ST	ST US	Wamsi Mohan
	Synnex Corp	SNX	SNX US	Ruplu Bhattacharya
	TE Connectivity Ltd.	TEL	TEL US	Wamsi Mohan
	Western Digital Corporation	WDC	WDC US	Wamsi Mohan
NEUTRAL				
	Avnet Inc.	AVT	AVT US	Ruplu Bhattacharya
	Celestica	CLS	CLS US	Ruplu Bhattacharya
	Celestica	YCLS	CLS CN	Ruplu Bhattacharya
	Jabil Inc.	JBL	JBL US	Ruplu Bhattacharya
	NetApp Inc.	NTAP	NTAP US	Wamsi Mohan
	Sanmina Corporation	SANM	SANM US	Ruplu Bhattacharya
	Teradata Corporation	TDC	TDC US	Wamsi Mohan
UNDERPERFORM				
	3D Systems Corporation	DDD	DDD US	Wamsi Mohan
	Arrow Electronics Inc.	ARW	ARW US	Ruplu Bhattacharya
	Seagate Technology	STX	STX US	Wamsi Mohan
	Stratasys Ltd.	SSYS	SSYS US	Wamsi Mohan
	Vishay Intertechnology, Inc.	VSH	VSH US	Ruplu Bhattacharya
RSTR				
	HP Inc.	HPQ	HPQ US	Wamsi Mohan
	Tech Data Corp.	TECD	TECD US	Ruplu Bhattacharya



US - Semiconductors and Semiconductor Capital Equipment Coverage Cluster

Investment rating	Company	BofA Ticker	Bloomberg symbol	Analyst
BUY				
	Advanced Micro Devices, Inc	AMD	AMD US	Vivek Arya
	Analog Devices Inc.	ADI	ADI US	Vivek Arya
	Applied Materials, Inc.	AMAT	AMAT US	Vivek Arya
	Broadcom Inc	AVGO	AVGO US	Vivek Arya
	Inphi Corporation	IPHI	IPHI US	Vivek Arya
	Intel	INTC	INTC US	Vivek Arya
	KLA-Tencor Corp.	KLAC	KLAC US	Vivek Arya
	Lam Research Corp.	LRCX	LRCX US	Vivek Arya
	Marvell Technology Group Ltd.	MRVL	MRVL US	Vivek Arya
	Microchip	MCHP	MCHP US	Vivek Arya
	NVIDIA Corporation	NVDA	NVDA US	Vivek Arya
	NXP Semiconductors NV	NXPI	NXPI US	Vivek Arya
	Qorvo Inc.	QRVO	QRVO US	Vivek Arya
	Skyworks Solutions, Inc.	SWKS	SWKS US	Vivek Arya
	Synopsys	SNPS	SNPS US	Adam Gonzalez, CFA
	Texas Instruments Inc.	TXN	TXN US	Vivek Arya
NEUTRAL				
	Cadence	CDNS	CDNS US	Adam Gonzalez, CFA
	Teradyne	TER	TER US	Vivek Arya
UNDERPERFORM				
	Ambarella	AMBA	AMBA US	Adam Gonzalez, CFA
	Cirrus Logic	CRUS	CRUS US	Adam Gonzalez, CFA
	M/A-Com	MTSI	MTSI US	Vivek Arya
	Maxim Integrated Products Inc.	MXIM	MXIM US	Vivek Arya
	ON Semiconductor	ON	ON US	Vivek Arya
	Xilinx Inc.	XLNX	XLNX US	Vivek Arya
RSTR				
	Cypress	CY	CY US	Vivek Arya

Disclosures

Important Disclosures

Equity Investment Rating Distribution: Media & Entertainment Group (as of 31 Dec 2019)

Coverage Universe	Count	Percent	Inv. Banking Relationships*	Count	Percent
Buy	27	39.71%	Buy	13	48.15%
Hold	17	25.00%	Hold	8	47.06%
Sell	24	35.29%	Sell	10	41.67%

Equity Investment Rating Distribution: Technology Group (as of 31 Dec 2019)

Coverage Universe	Count	Percent	Inv. Banking Relationships*	Count	Percent
Buy	159	58.89%	Buy	99	62.26%
Hold	47	17.41%	Hold	32	68.09%
Sell	64	23.70%	Sell	30	46.88%

Equity Investment Rating Distribution: Telecommunications Group (as of 31 Dec 2019)

Coverage Universe	Count	Percent	Inv. Banking Relationships*	Count	Percent
Buy	81	54.73%	Buy	57	70.37%
Hold	30	20.27%	Hold	17	56.67%
Sell	37	25.00%	Sell	17	45.95%

Equity Investment Rating Distribution: Global Group (as of 31 Dec 2019)

Coverage Universe	Count	Percent	Inv. Banking Relationships*	Count	Percent
Buy	1560	50.49%	Buy	991	63.53%
Hold	717	23.20%	Hold	461	64.30%
Sell	813	26.31%	Sell	415	51.05%

* Issuers that were investment banking clients of BofA Securities or one of its affiliates within the past 12 months. For purposes of this Investment Rating Distribution, the coverage universe includes only stocks. A stock rated Neutral is included as a Hold, and a stock rated Underperform is included as a Sell.

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Investment rating	Total return expectation (within 12-month period of date of initial rating)	Ratings dispersion guidelines for coverage cluster*
Buy	≥ 10%	≤ 70%
Neutral	≥ 0%	≤ 30%
Underperform	N/A	≥ 20%

* Ratings dispersions may vary from time to time where BofA Global Research believes it better reflects the investment prospects of stocks in a Coverage Cluster.

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