

# Content Chain Trends

## Content Infrastructure & Storage



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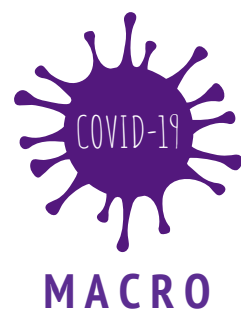
# State of Content Infrastructure & Storage





# State of Content Infrastructure and Storage

## Macro Trends



The global shortage of semiconductors and other components further increased in the second half of 2021, causing bottlenecks in production and sales.



Physical distancing guidelines accelerated the decline in physical tech, resulting in falling revenues for vendors heavily reliant on physical offerings.



The decentralization of resources and shift to remote production increased investment in cloud and IP-based workflows, enabling shared access and collaboration.



The content-led streaming boom funneled investment in immersive, interactive content (increasing file size), driving spending on high-performance storage technology and consolidation of databases.



The pandemic accelerated media businesses' move to the cloud and remote production, dictating their investment in IP and cloud-native media tech.



Increasing demand for low latency and remote connectivity is shifting investment to focus on edge computing via cloud and even 5G.

Sources: IABM

# State of Content Infrastructure and Storage

## Key Technologies & Drivers



### IP



Decentralized remote production

Crew consolidation

Remote control & monitoring

### Cloud

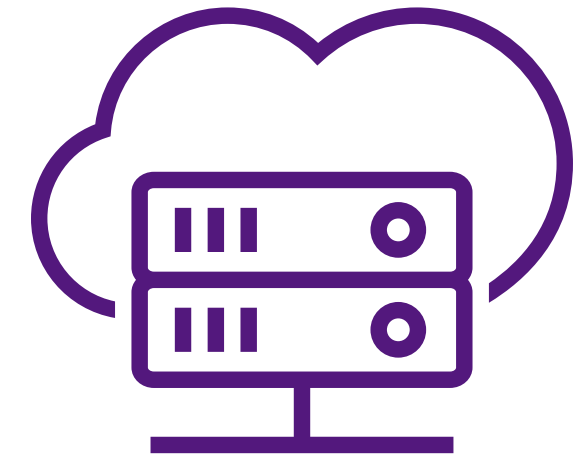


Decentralized remote production

Scalability & Speed

Collaboration & shared access

### Edge



Low latency for remote production, immersive & interactive experiences

Fast time-to-market in new regions

Shared access for virtualized studios & post-production

Sources: IABM



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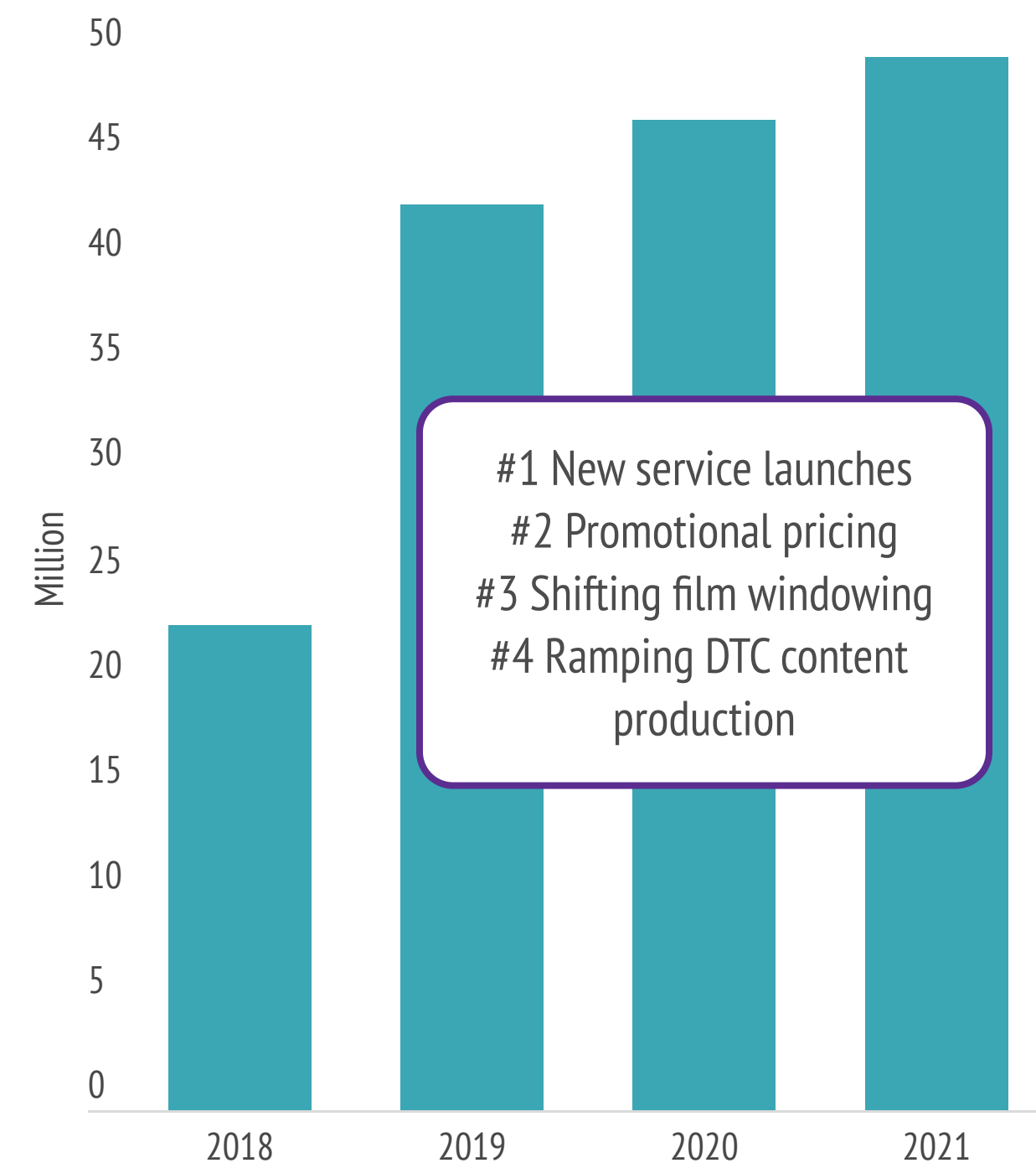
## Impact of streaming on storage and connectivity

**Better UX:** The content-led streaming boom increased demand for active archives and edge computing in 2021. Heavy focus on streaming pushed media companies to invest in IP networking and internet connectivity, improving productivity in content production and delivery, and augmenting UX - a key differentiator in the ever more crowded streaming space. At the same time, demand for legacy systems like fiber and satellite declined.

**More bandwidth:** An explosive growth of data volumes (and file size) has resulted in a rising demand for bandwidth. Also, the trend toward immersive, interactive content in streaming means that streaming players need to increasingly invest in low latency applications and solutions, translating into the adoption of more data efficient codecs allowing higher quality content and multi-CDN traffic.

**Smart storage:** The move to DTC business models, remote and decentralized productions requires better accessibility and discoverability of content, translating into an increasing need for dynamic, active (AI-supported) storage with lower latencies to retrieve data and to reduce application response times.

Total new streaming video subscribers in the US



Sources: IABM

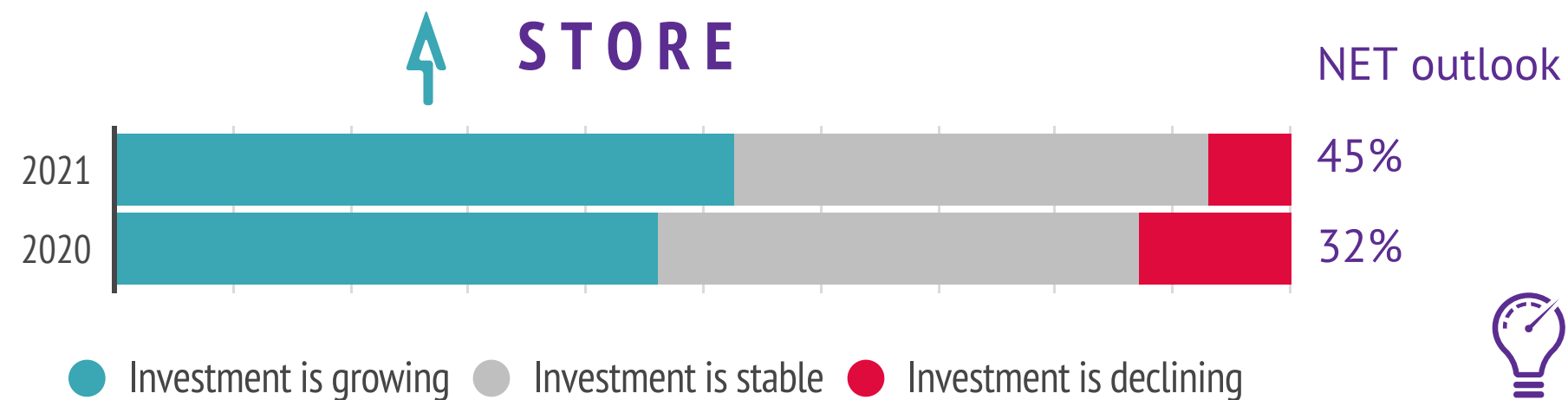
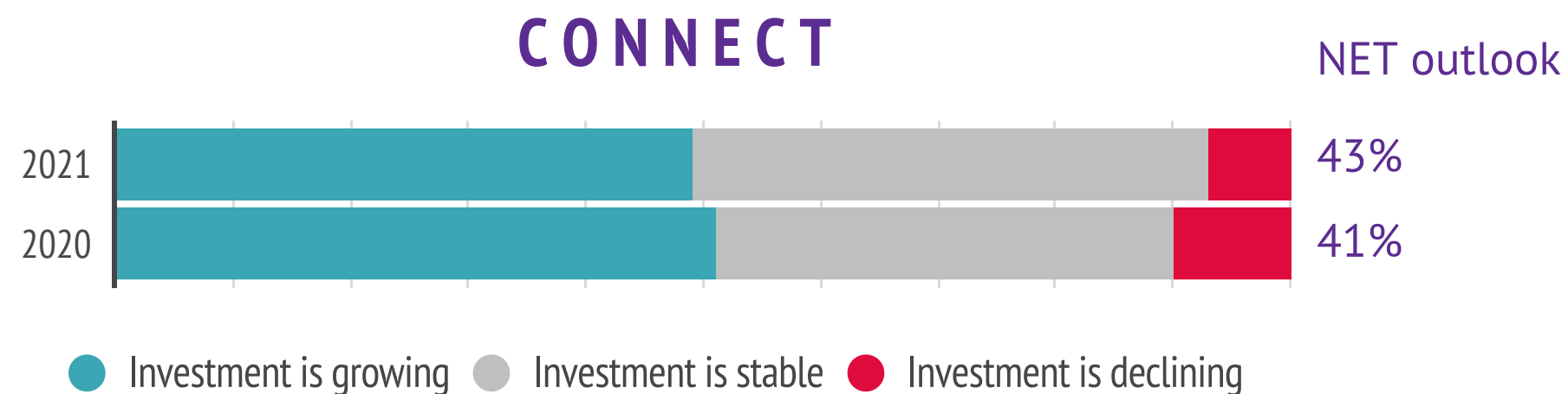




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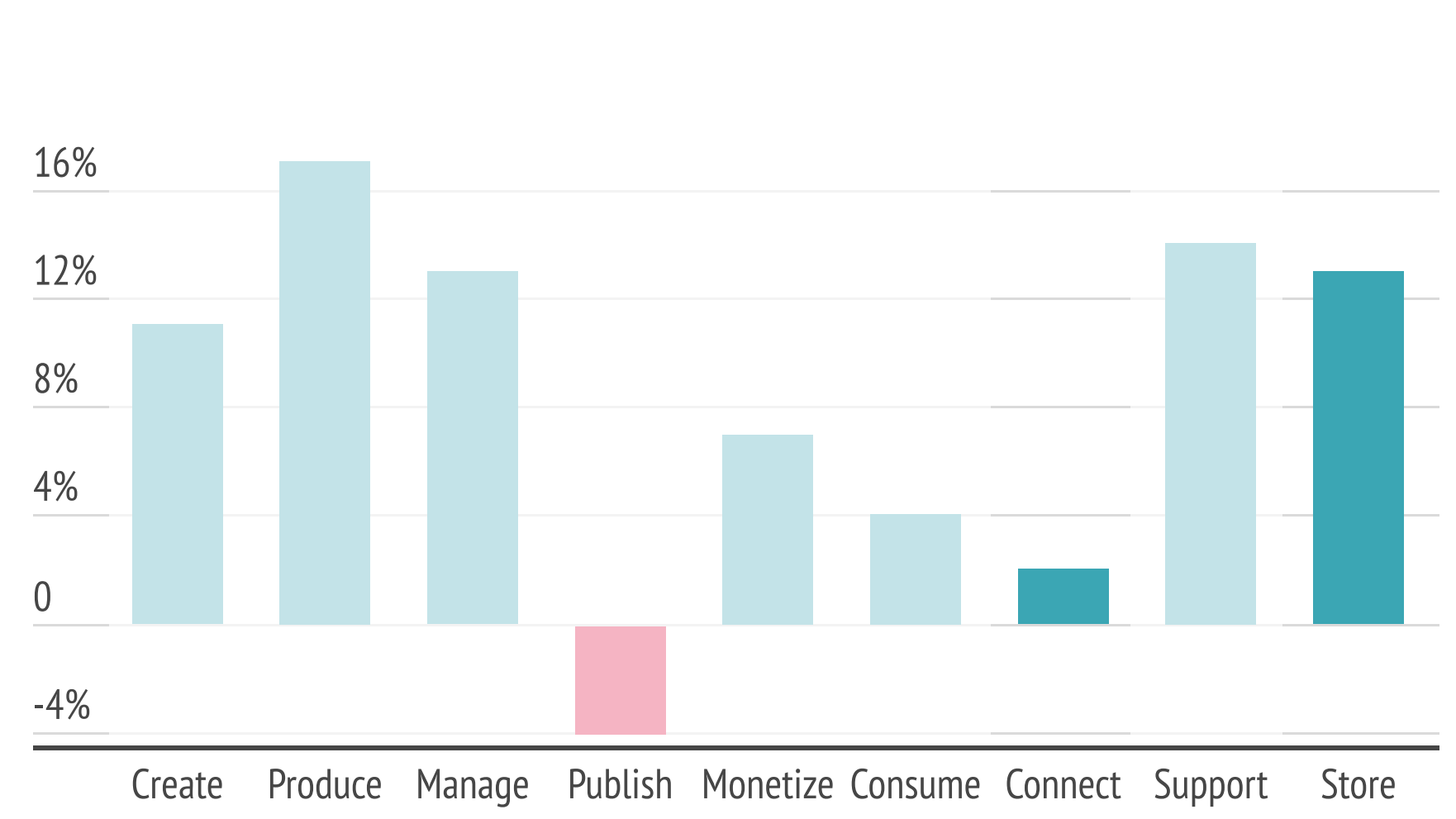
## Investment in Connect and Store

The investment outlook for Connect was stable over the last two years, with about 50% of media businesses saying investment in content infrastructure was growing. The investment outlook in content storage slightly improved in 2021 compared with the previous year, with half of the media businesses predicting growth of investment in storage capabilities.



### Change in NET investment outlook

NET = Growing - Declining, Change 2021 - 2020 is illustrated on the chart



Sources: IABM



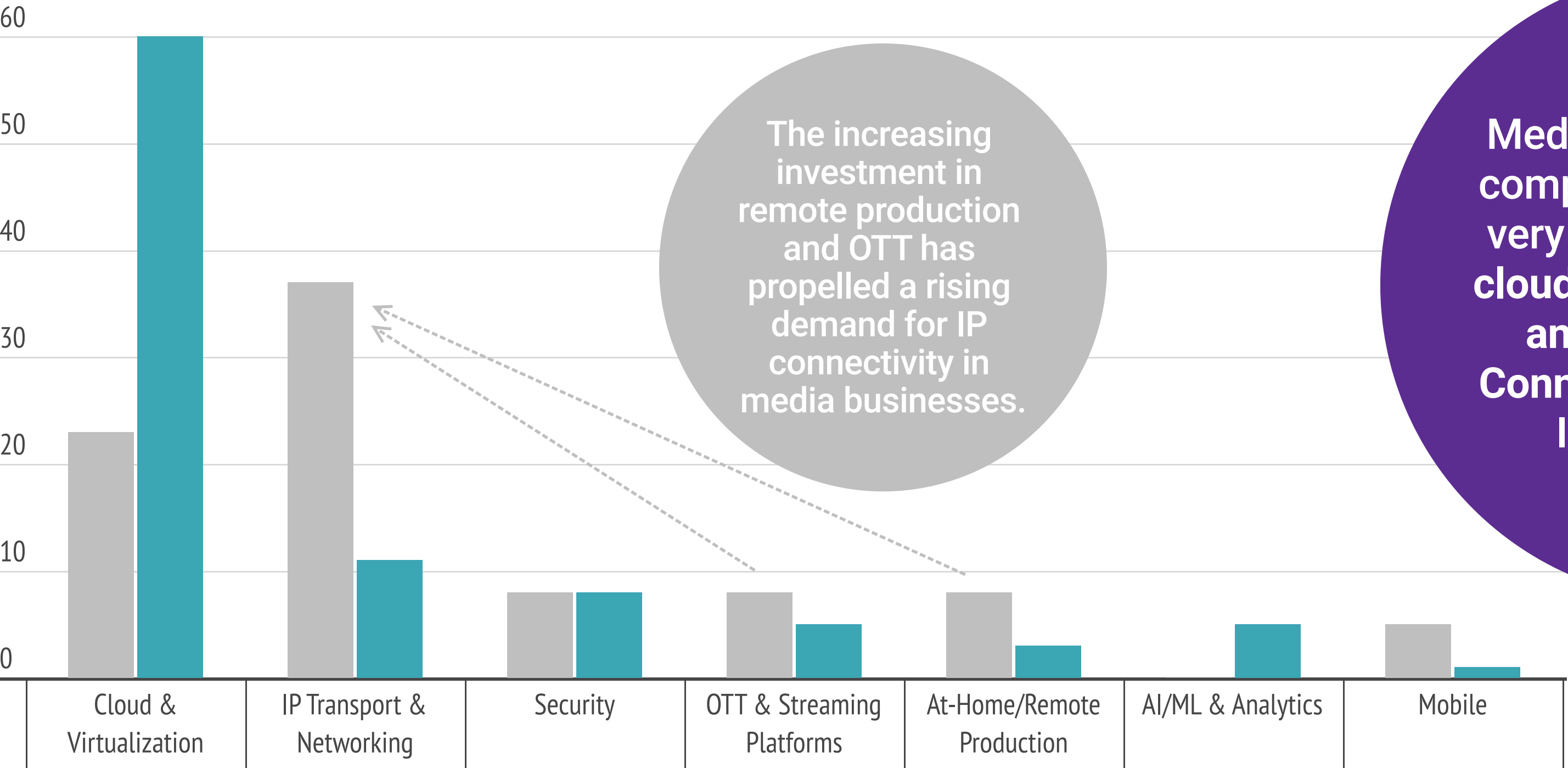
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## Investment in Connect and Store

### Investment Drivers

● Connect ● Store



The increasing investment in remote production and OTT has propelled a rising demand for IP connectivity in media businesses.

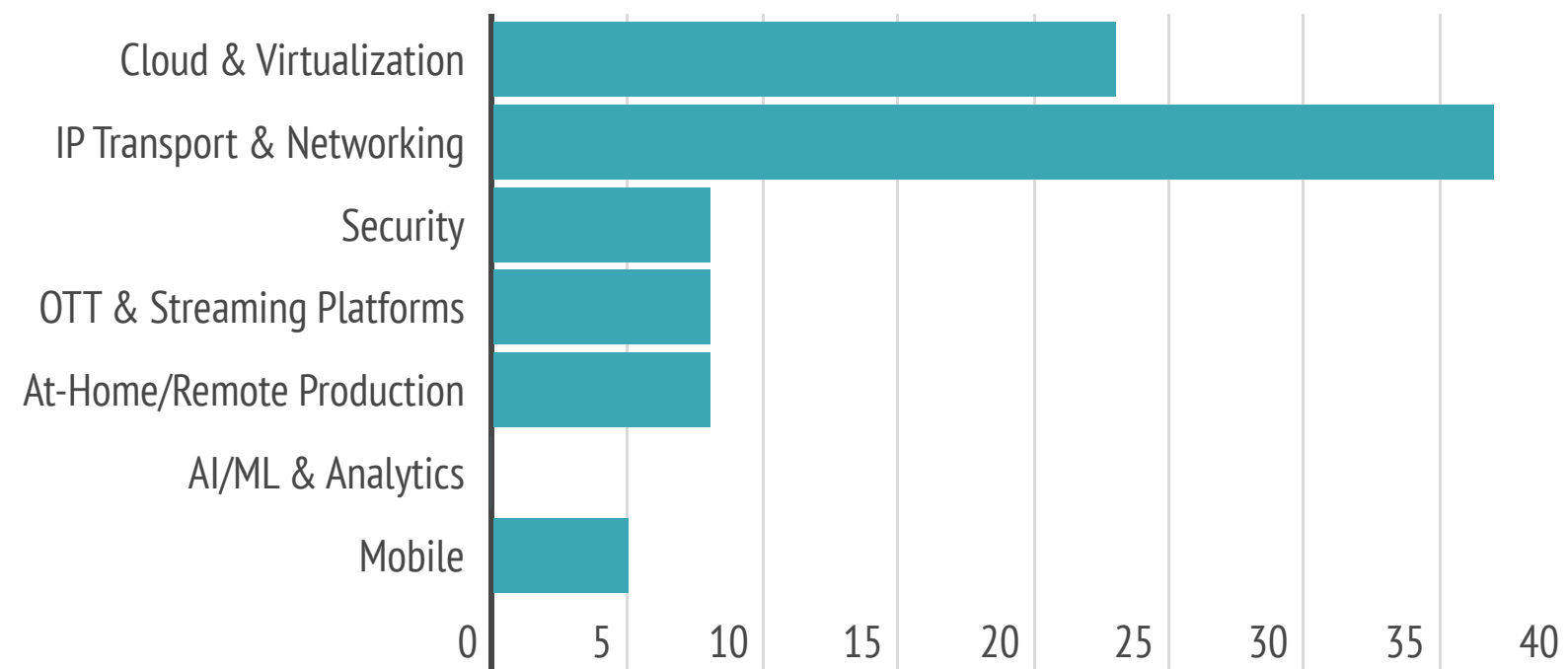
Media and technology companies in Store are very much focused on cloud and virtualization, and investment in Connect is focused on IP connectivity.

Sources: IABM

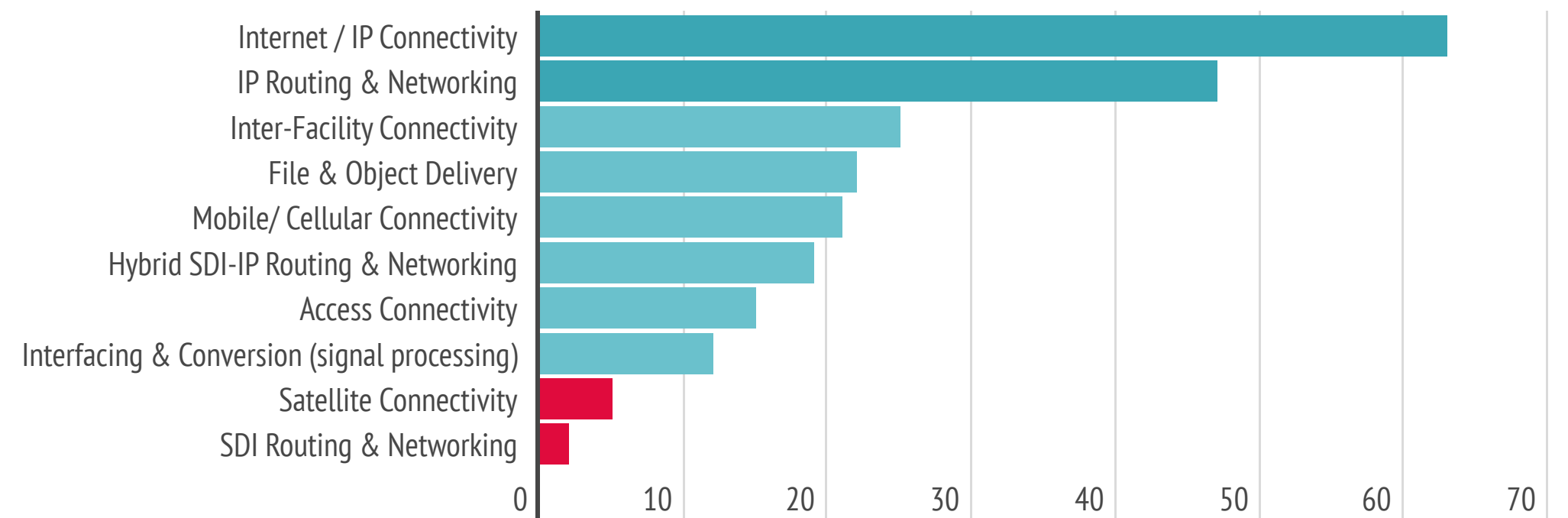
# State of Content Infrastructure & Storage

## Investment in Connect and Store

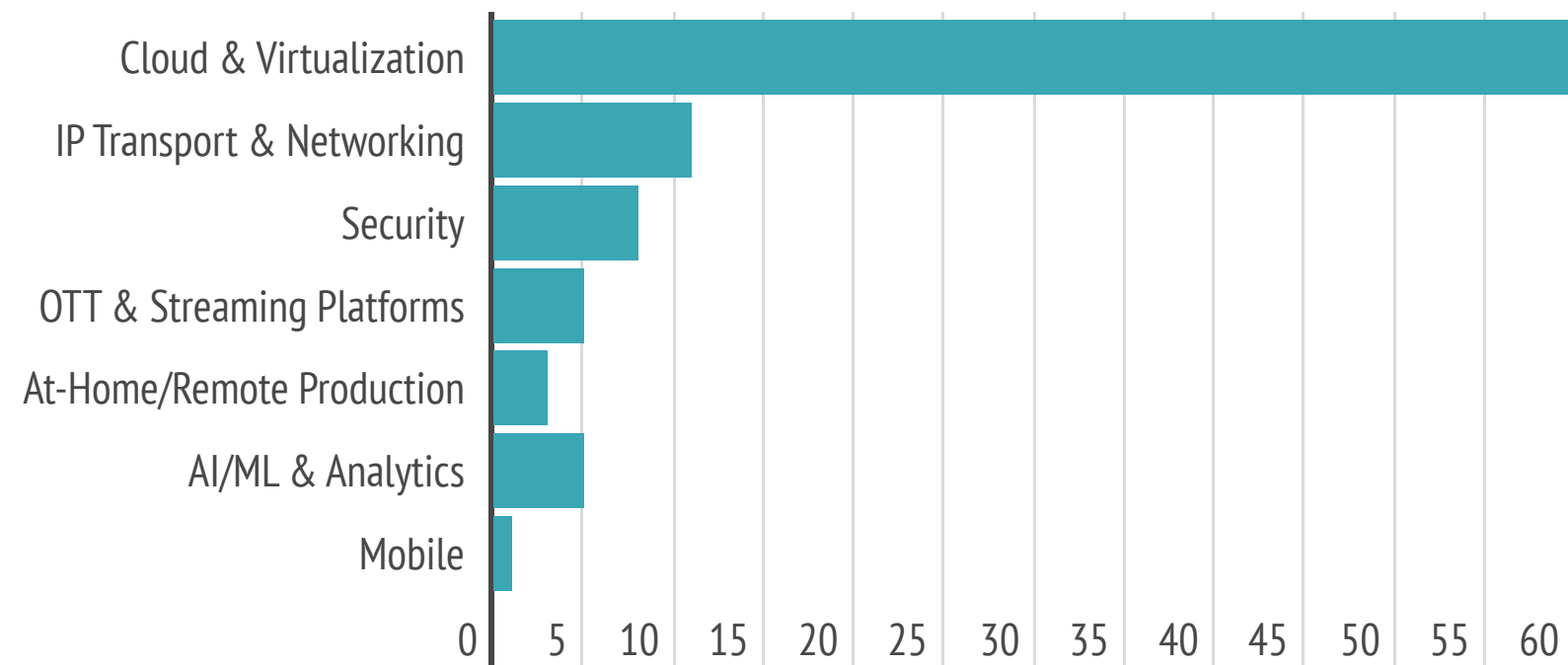
### Top investment drivers in Connect



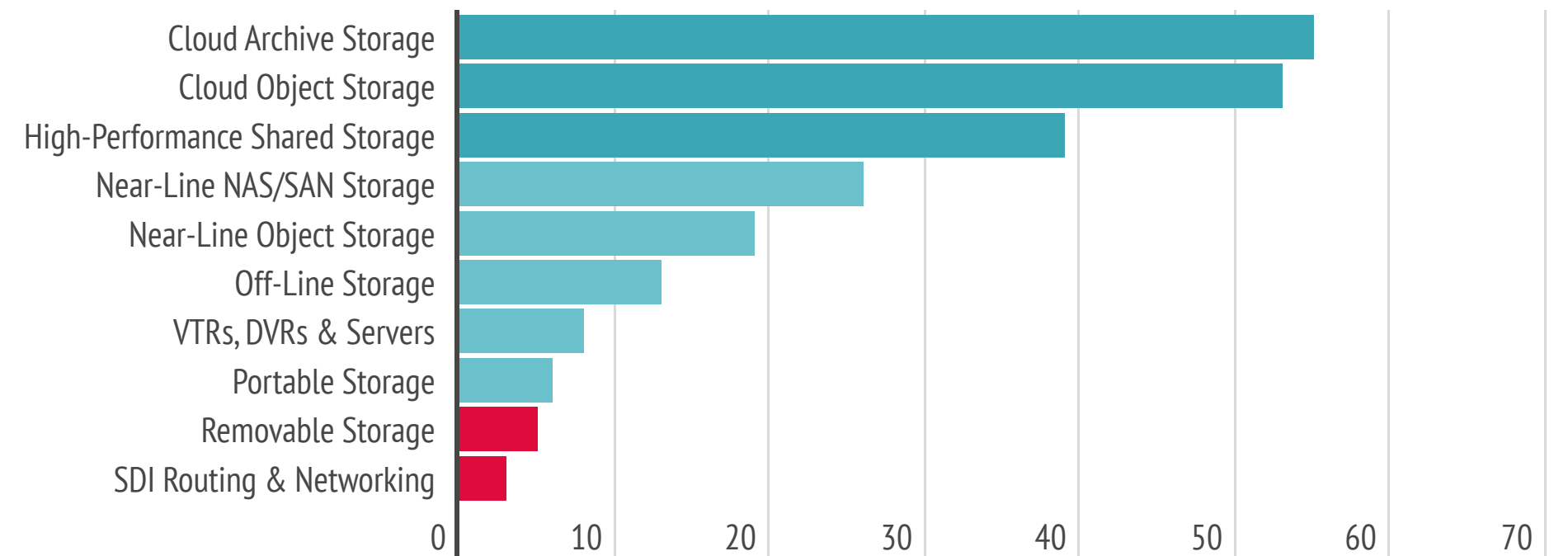
### Investment areas in Connect



### Top investment drivers in Store



### Investment areas in Store



Sources: IABM

# State of Content Infrastructure & Storage

## Investment in Connect and Store



### Investment drivers in Connect

### Investment drivers in Store



Transition from SDI to IP is driving new investment in infrastructure	Growth in content investment is driving more spending on storage solutions
Cloud adoption and remote production are driving new investment in internet connectivity resources	Transition to remote working, cloud, and remote production is driving new investment in cloud-based storage
Transition to cloud is driving new investment in managing and securing cloud infrastructure	Increasing demand for edge computing, driven by demand for interactivity, immersive experiences, and low latency
Declining investment in legacy connectivity technologies, such as SDI and satellite	Declining investment in physical and travel-dependent storage technologies
Cloud and remote production are driving a rationalization of resources that is impacting certain categories	
Declining investment in hardware-based offerings, which accounts for a large share of revenues in this segment	



Sources: IABM



# Business and Tech Trends

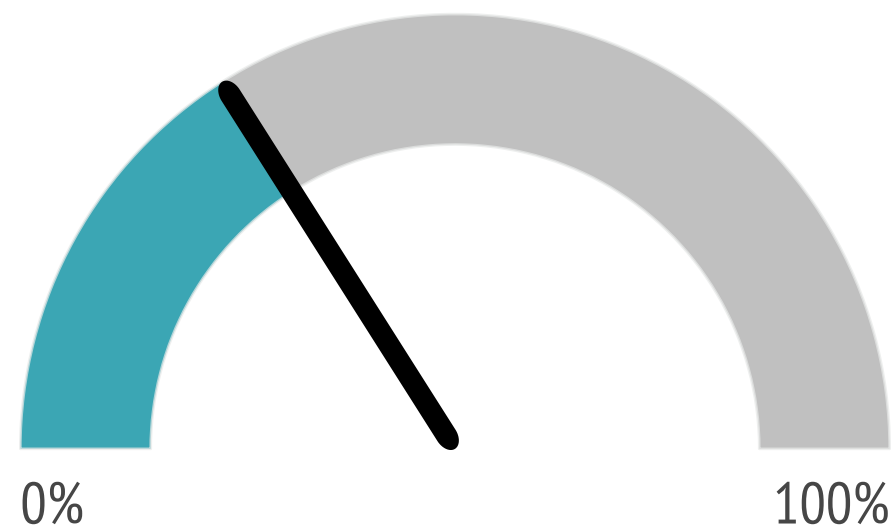


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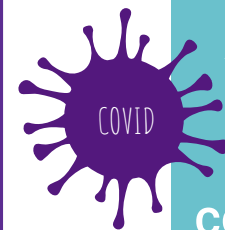
## Transition to IP infrastructure

### Adoption of IP infrastructure



● Have transitioned from SDI to IP

According to IABM research, 32% of media businesses have already upgraded their infrastructures from SDI to IP.



IP in Cloud operating platforms	IP in Remote production	IP in Direct-to-consumer
<p>A temporary slowdown of major greenfield/uncompressed IP projects was compensated by compressed IP projects and public cloud deployments</p>	<p>Move away from centralized, studio-based SDI operations to IP-based decentralized, remote productions</p>	<p>Improved productivity, interconnectivity/interoperability between vendor solutions facilitating investment in IP</p>
<p>Hybrid SDI/IP approach is still preferred as an interim solution among broadcasters due to their existing legacy equipment</p>	<p>New codecs and protocols supporting IP-based live production easing the delivery of higher resolution formats</p>	<p>Trend toward interactive, gamified content requiring higher bandwidth boosting demand for ST2110 (for 8K streaming over IP)</p>
<p>The accelerated transition to IP is causing scarcity of skillsets required in IP-related roles, forcing media companies to compete for talent and driving wage inflation.</p>	<p>Improved productivity, interconnectivity/interoperability between vendor solutions facilitating investment in IP</p>	<p>Accelerated adoption of the HEVC codec reflecting the industry's permanent shift to live video streaming of 4K/UHD content</p>

Sources: IABM

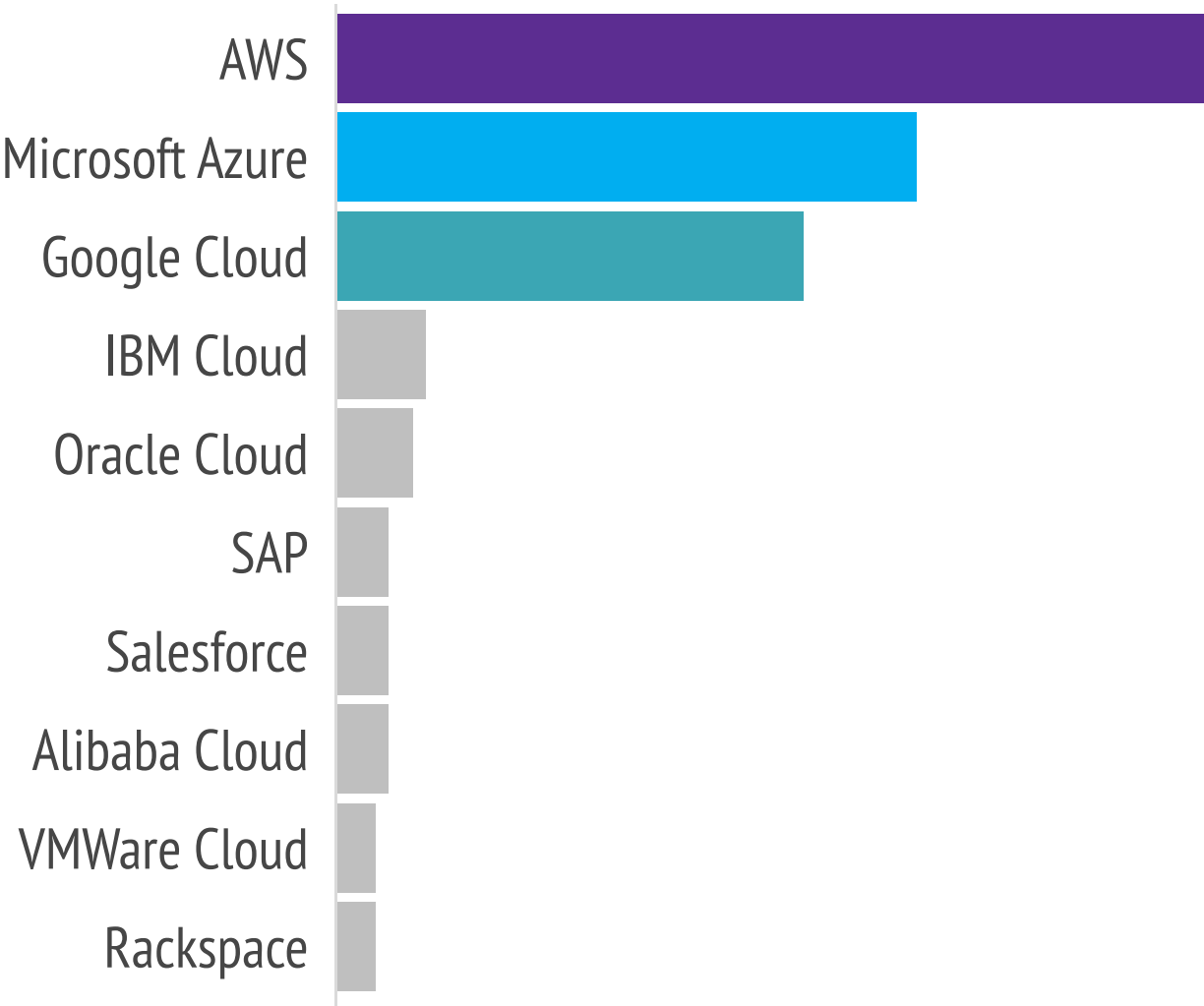
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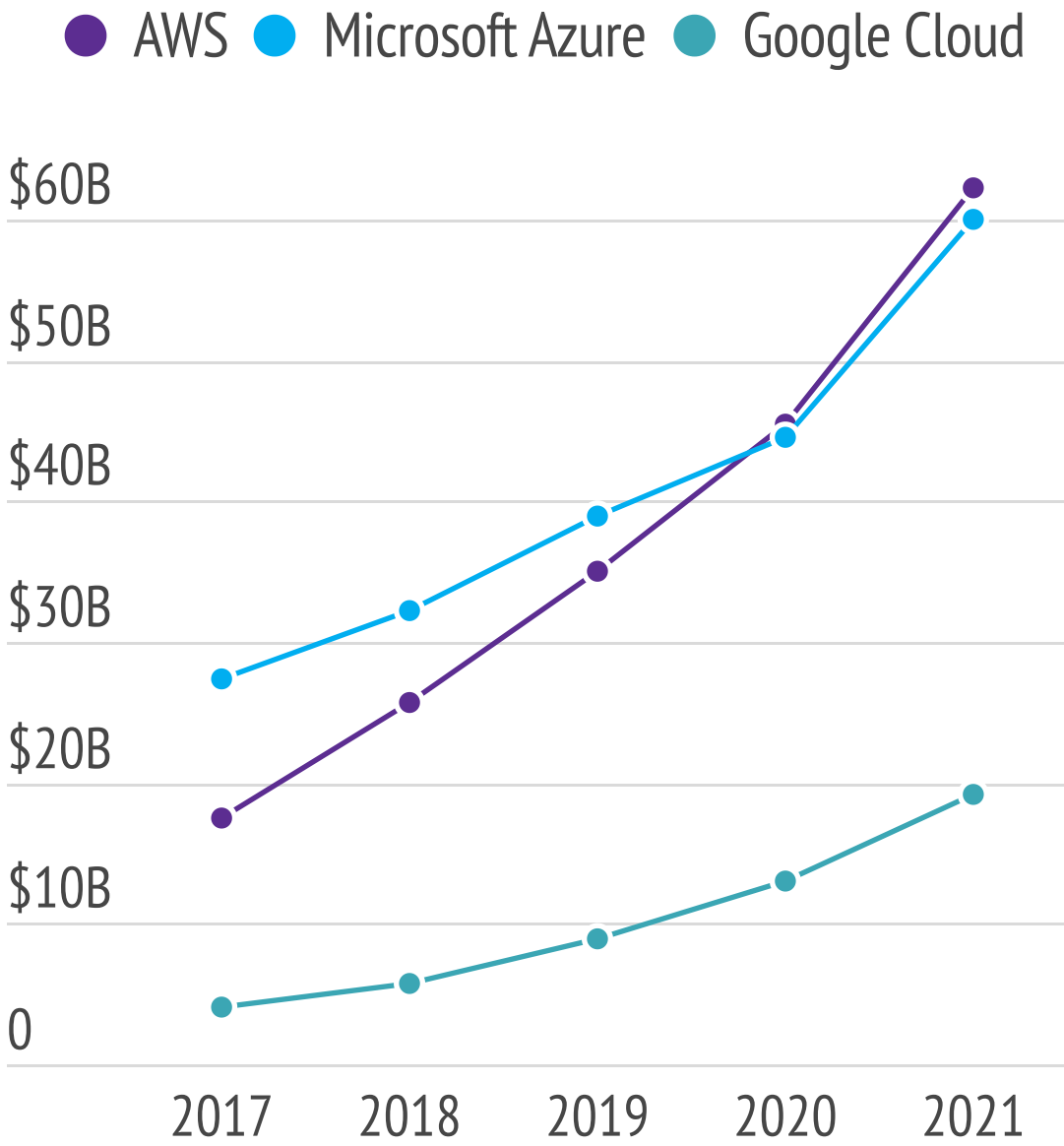
## Transition to cloud operating platforms

AWS and Microsoft Azure are leading by global revenue, and Google Cloud is growing in revenue faster than other top cloud service providers. Cloud service providers' revenue growth has restarted in 2021.

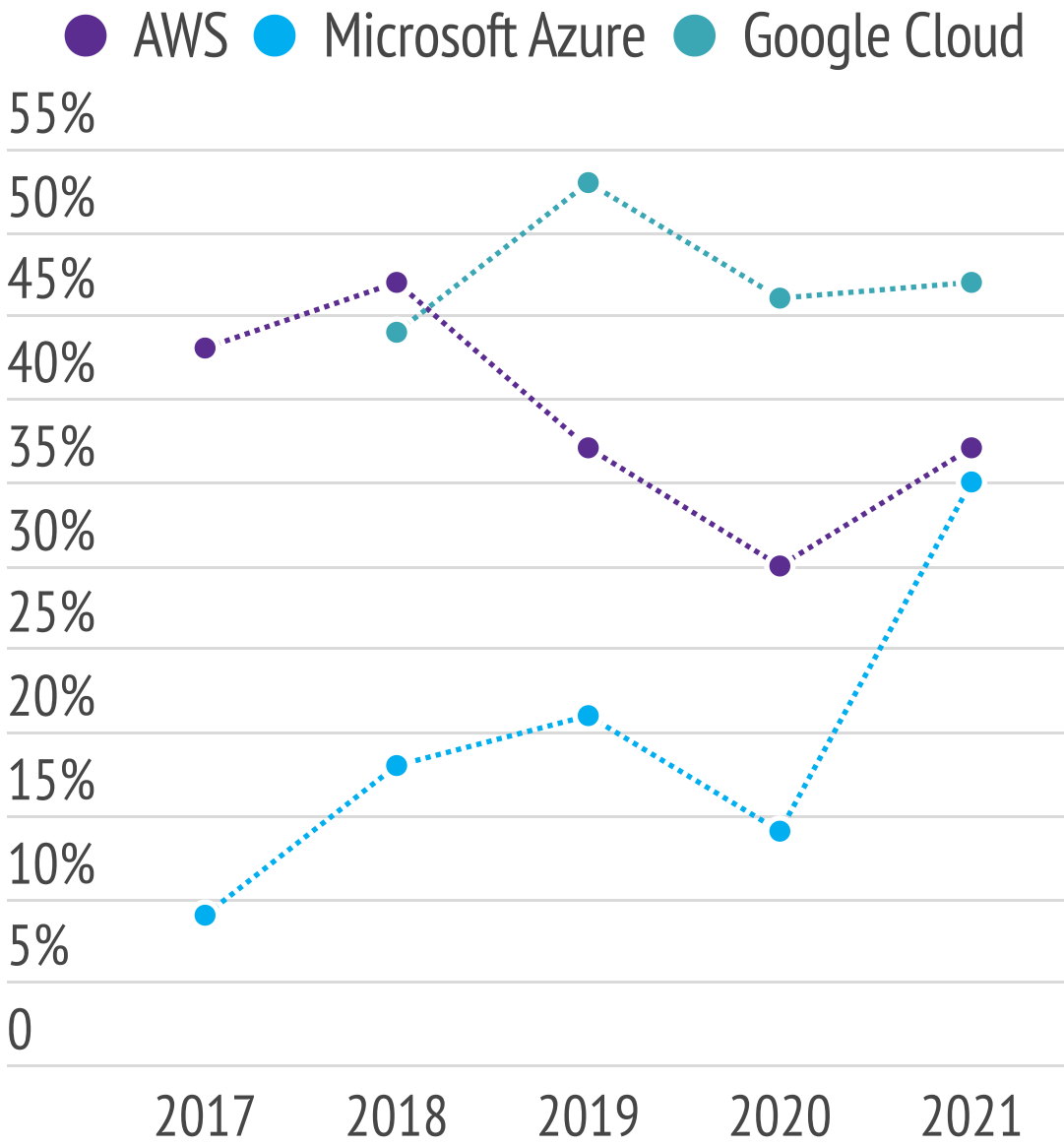
Cloud service providers usage by media businesses



Global revenue in billion USD



Global revenue YoY growth rate



Sources: IABM, Company filings

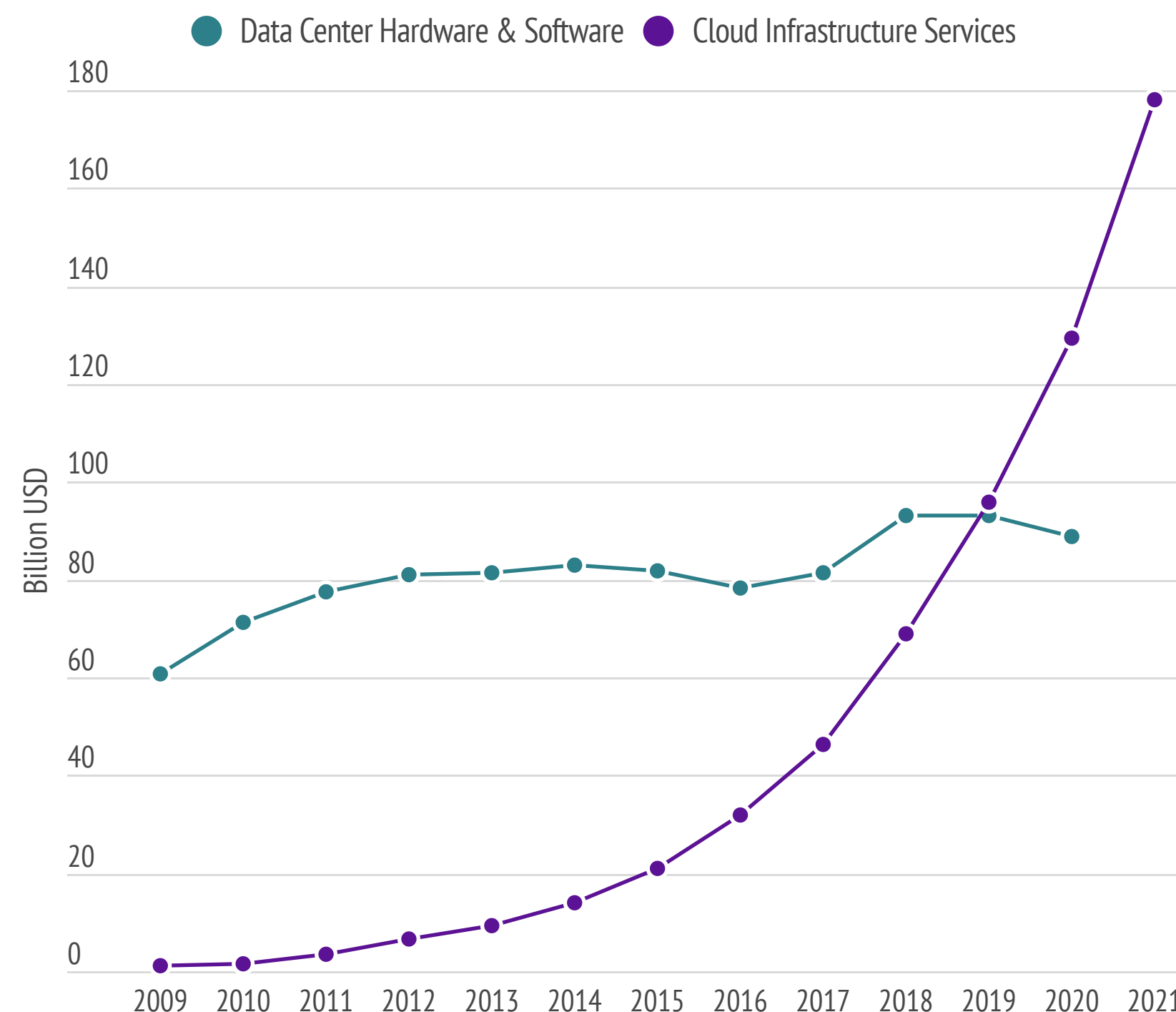


# State of Content Infrastructure & Storage

## Transition to cloud operating platforms

In addition to the drive for operational flexibility, agility and scalability, faster time to (new) market and better geographical reach are increasingly central drivers of cloud investment - remotely working decentralized production teams need shared real-time access to virtualized studios. Big streaming players like Netflix, Disney and Amazon have invested in new, emerging markets and local content production. At the same time, these players are diversifying their strategic focus to immersive, interactive, gamified content, which significantly increases data volumes and operational complexity. Given the accelerating fragmentation of viewing across different devices, cloud infrastructure has a central role in enabling viewers to enjoy live transmission of higher content formats and interactive features independent of the receiving device.

Enterprise spending on cloud and data centers globally 2009-2021



Sources: IABM, Synergy Research Group, Statista estimates





# State of Content Infrastructure & Storage

## Transition to edge computing

### Why edge?

As demand for live video streaming continues to explode, media businesses increasingly rely on edge computing, which brings a host of flexible cloud computing functions - and powerful processing power - to the point where the video is created. This enables media companies to deploy a highly scalable edge computing-powered platform directly at the source to perform any task based on the available processing power, software applications, and storage instead of having a fixed device capable of processing only one task. By bringing this capacity as close to the video source as possible, media companies can reduce latency, simplify their live video workflows and - most importantly - reduce operational costs.



A key benefit of edge computing is its innovation potential, enabling media businesses to innovate, adapt and rebuild functions and new capabilities needed for the creation of customized live video workflows. For example, broadcasters can use edge computing capabilities at the point of video origination (e.g., in a sporting event) to get more feeds into their production workflow without investing in additional expensive encoding equipment (many content creators still use lower-end video encoders offering limited functionality), when the cloud acts as an intermediary for processing video streams and distributing them to the selected platforms. This is touted to be cheaper and more flexible than using traditional broadcast-grade equipment.



*With [edge computing-powered] AWS Local Zones in close proximity to our production hubs, shoots, and the famed Fox lot, we're able to deliver cloud resources directly to our artists, allowing them to craft their vision without the limitations of traditional remote solutions. Creative workflows like editorial, motion graphics, and finishing demand ultra-low latency.*

*Christian Kennel  
VP Post & Production Technology  
FOX Entertainment*

Sources: IABM, tvtechnology.com, streamingmedia.com, broadcastprome.com



# State of Content Infrastructure & Storage

## Transition to edge computing

Media businesses' move towards decentralized remote production is driving investment in edge computing and cloud storage, which brings new efficiencies to TV and film production through shared access and virtual management of huge video files. Edge computing brings cloud resources closer to decentralized (post-) production teams, enabling low latency access to virtual workstations, especially benefitting artists creating visual effects, immersive content and games with very large file sizes. In February 2022, AWS announced that it would expand its edge computing infrastructure - Local Zones - to 32 cities around the world. At the same time, Akamai - a major player in edge computing - announced its acquisition of Linode, an edge computing company, for US\$900 million, which will enable Akamai to build a cloud platform and run and secure applications from the cloud to the edge.

”

*In order to provide a good working experience for our artists, they need **low latency** access to their **virtual workstations**. AWS Local Zones brings cloud resources closer to our artists and have been a game changer for these applications. By taking advantage of AWS Local Zones, we have migrated a portion of our content creation process to AWS while ensuring an even better experience for artists. We are excited about the expansion of AWS Local Zones globally, which brings cloud resources **closer to creators**, allowing artists to get to work **anywhere** in the world and create without boundaries.*

*Stephen Kowalski  
Director of Digital Production Infrastructure Engineering  
Netflix*

Sources: IABM, AWS, Verizon, martechseries.com

# State of Content Infrastructure & Storage

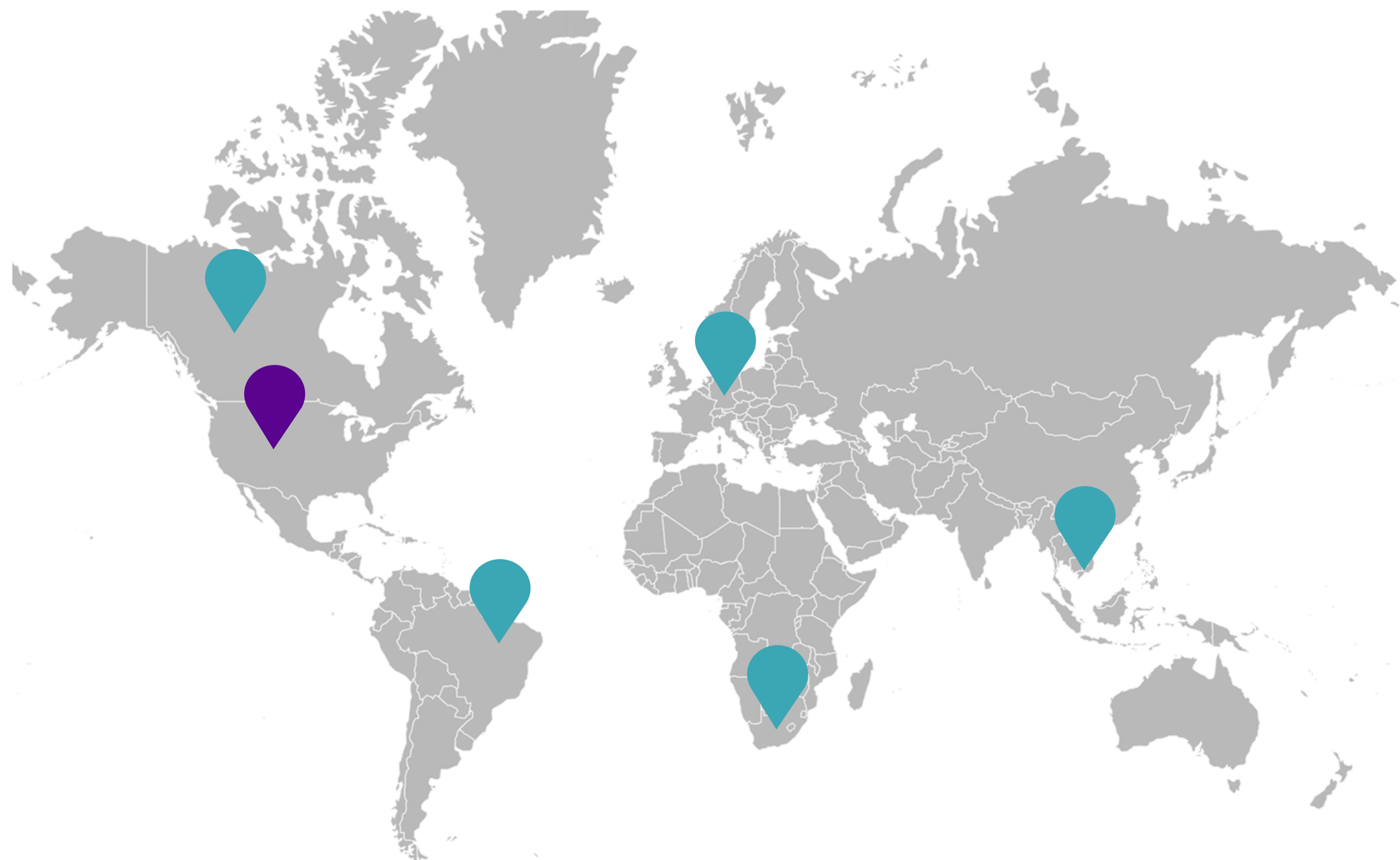
Transition to edge computing



## AWS Local Zones

Global expansion of Edge Computing Infrastructure

Existing Local Zones      New Local Zones



”

With AWS Local Zones, we’re able to deploy resources in **more geographic locations** across our multiple studios. This has been integral to the success of our crew members who are able to **access cloud studio servers** at such **low latency** that it almost feels like they’re using a computer locally.

*Ryan Thompson  
Co-Founder & CPO  
Esports Engine*

Sources: IABM, AWS, datacenterfrontier.com

# State of Content Infrastructure & Storage

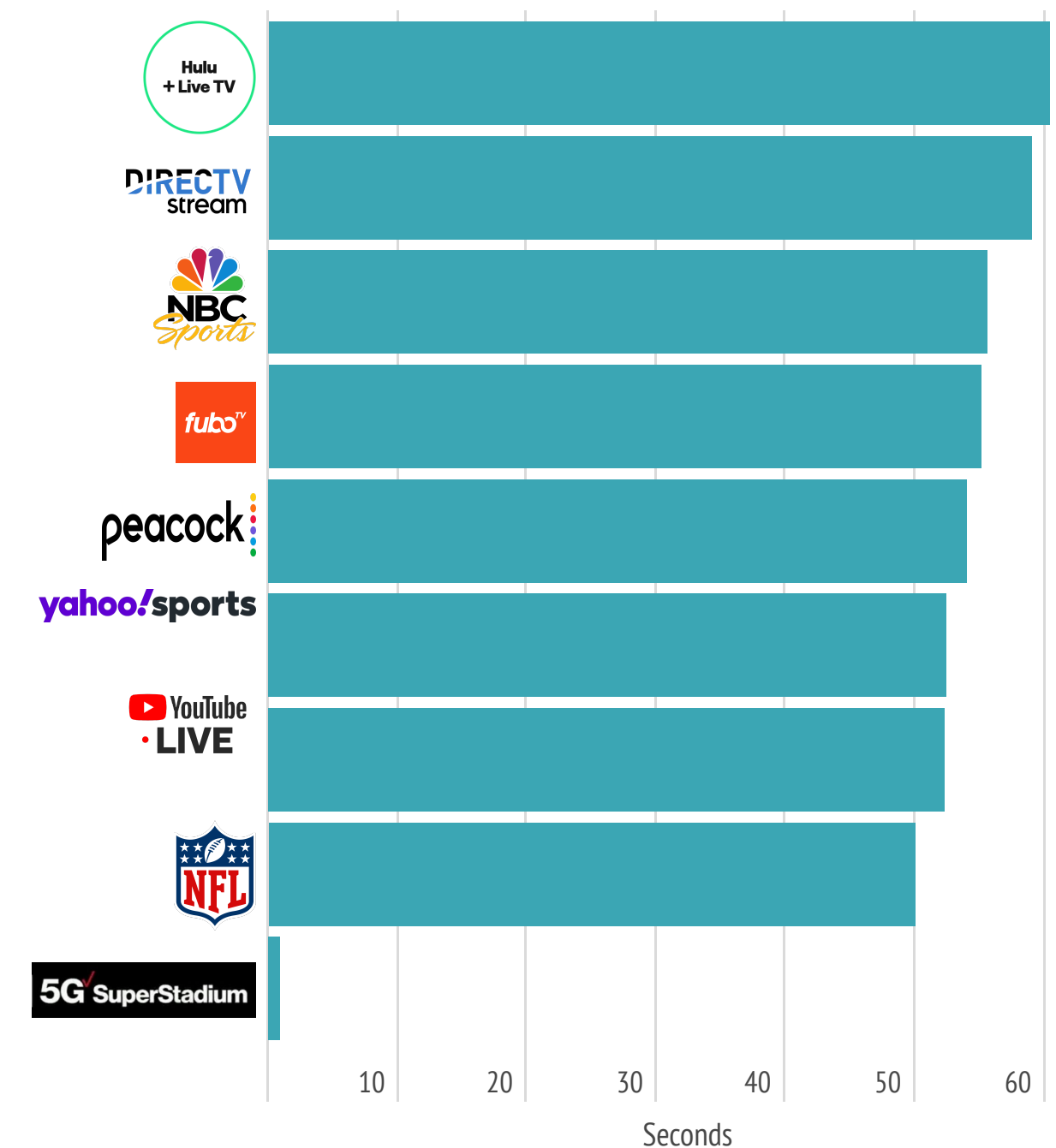


## Transition to edge computing

### 5G in low latency streaming and remote production

As viewers continue to cut the cord and move away from cable and over-the-air TV to streaming, latency issues related to streaming live OTT content are becoming more pronounced, particularly in sports, where even slight delay can lead to spoilers and a degraded UX. For example, during the 2022 Super Bowl, many major streaming platforms lagged behind the actual match 50-60 seconds. At the same time, Verizon's in-stadium 5G SuperStadium application had a latency of 0.9 seconds, illustrating significant market potential for 5G in live video streaming. The trend toward interactivity and gamification in streaming means that streaming players need to increasingly invest in low latency applications and solutions, translating into the adoption of more data efficient codecs allowing higher quality content and multi-CDN traffic.

### 2022 NFL Super Bowl Streaming latency by platform



Sources: IABM, newsweek.com, Phenix Real Time Solutions

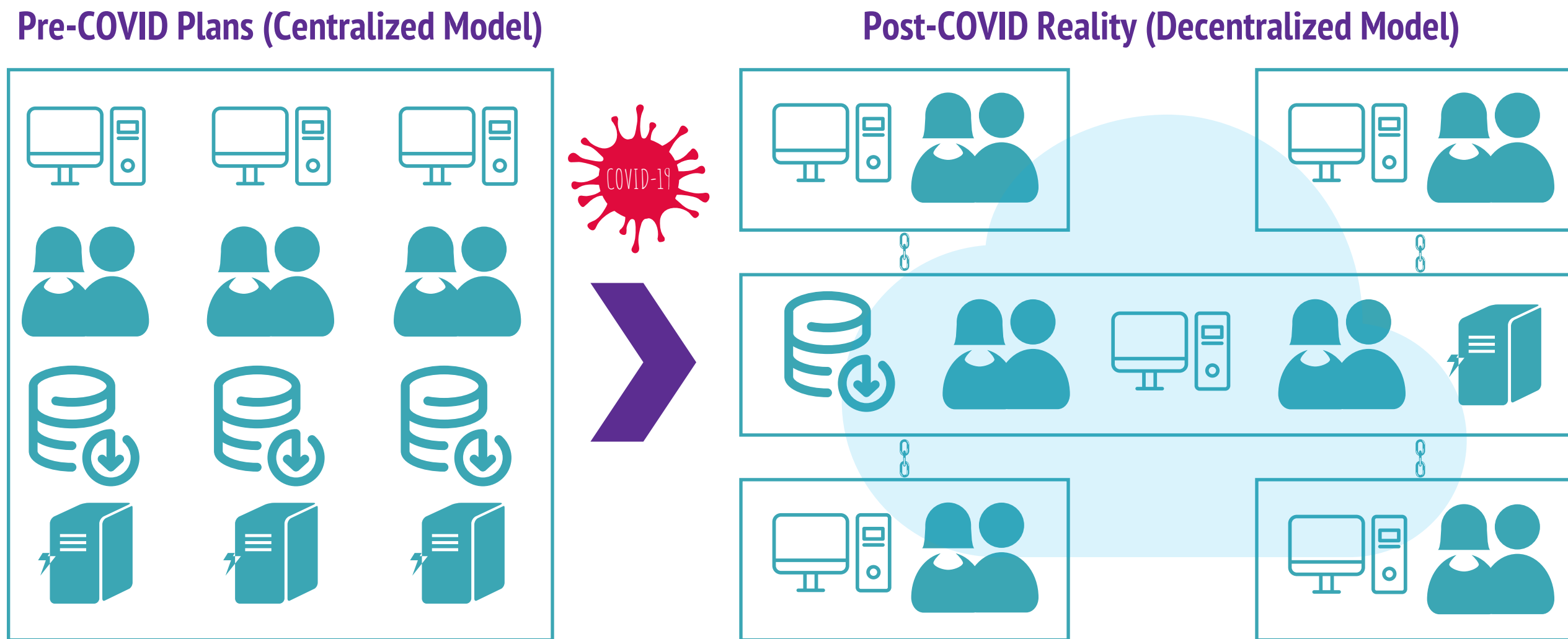




# State of Content Infrastructure & Storage

## Transition to remote production

The main benefit of remote production is often claimed to be in asset centralization in one facility, which in turn enables increased content coverage and resource productivity, as well as cost savings in terms of reduced travel expenses. The COVID-19 pandemic has forced media companies to quickly deploy decentralized remote production models, which has changed the direction of their R&D investments.



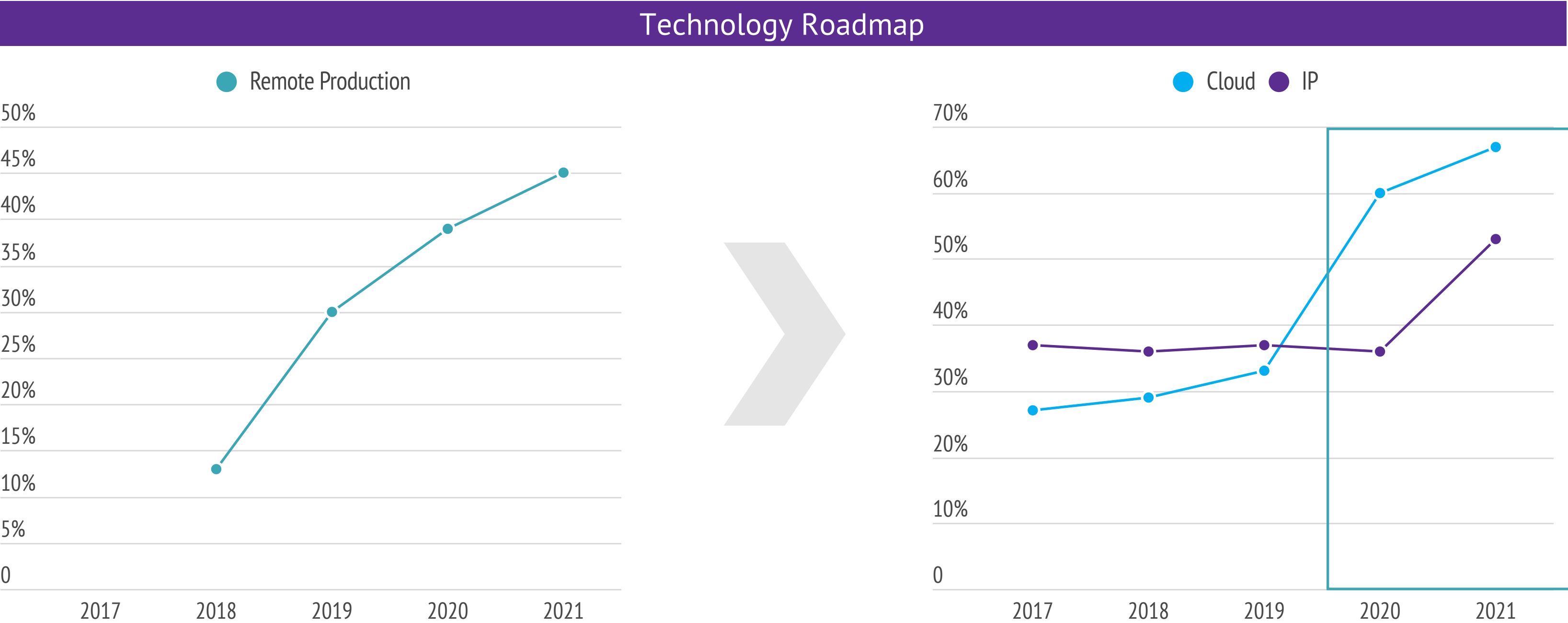
Sources: IABM

# State of Content Infrastructure & Storage



## Transition to remote production

The move to remote production has had a profound impact on infrastructure investment, contributing to increasing investment in cloud resources and IP connectivity.

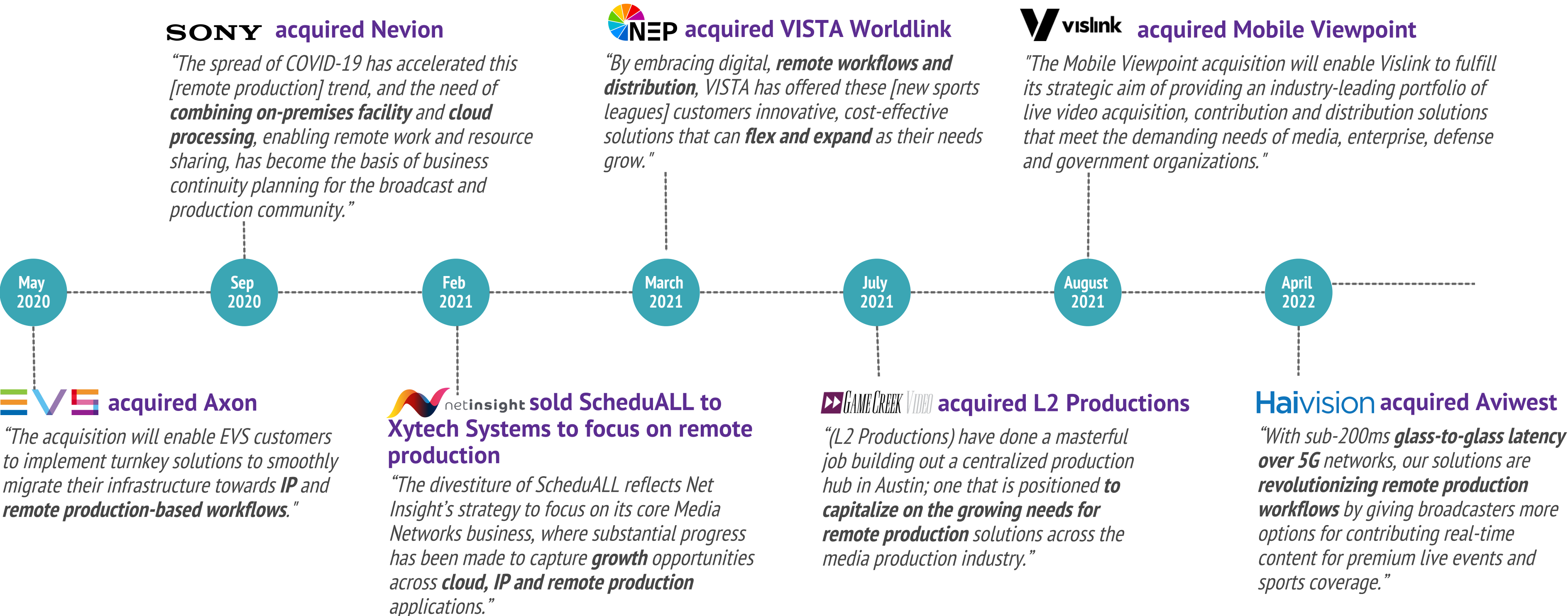


Sources: IABM

# State of Content Infrastructure & Storage



## Transition to remote production

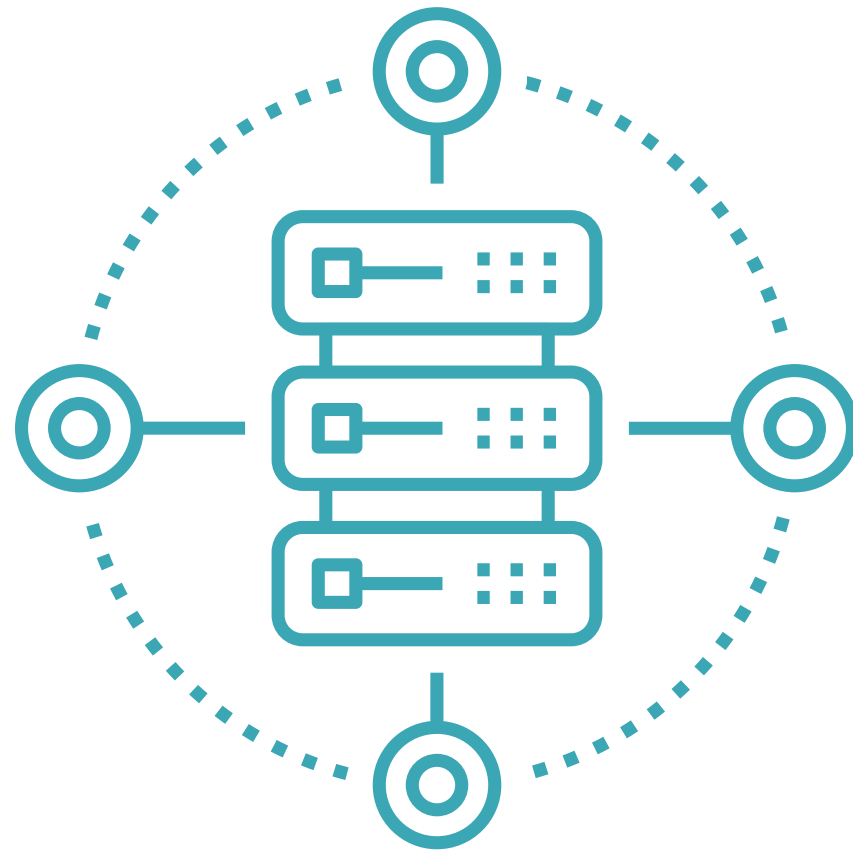


Sources: IABM, Company filings





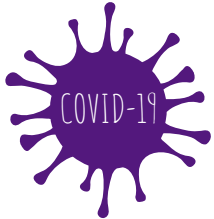
# Content Infrastructure Tech Trends



# Content Infrastructure Tech Trends



## Connectivity and bandwidth



IMPACT



IP

The COVID-19 pandemic significantly accelerated the move away from centralized, studio-based SDI operations to IP-based decentralized and remote productions

The streaming boom pronounced the benefits of natively IP-produced video, better suiting delivery to OTT and online streaming

The pandemic highlighted the need for agility to support higher resolution and connectivity of all infrastructure, increasing interest in SMPTE ST2110, enabling IP-based live production



Satellite

The pandemic caused a significant drop in major satellite operators' broadcast revenues due to broadcasters' focus shifting to internet distribution/streaming

Satellite operators are turning to emerging markets lacking reliable broadband but where the demand for content in local languages is increasing

Also in emerging markets, satellite operators are witnessing a slowdown in demand for their services, as it has become cheaper and easier for small TV channels to move to OTT



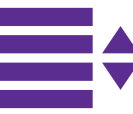
Cellular / 5G

Move to remote, live IP production multiplies the advantages of 5G networks as a complementary technology, allowing low latency for remote, decentralized productions

5G-supported production being increasingly tested/used in live sports, significantly reducing the need for production equipment, staff and satellite costs

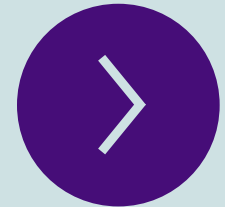
The increasing use of (5G) mobile networks and consumer devices supporting 5G is enabling new trials of mobile edge computing with 5G, enabling media companies to innovate and reshape their live video workflows

Sources: IABM, ViaSatellite, spacenews.com, IBC365, Avid

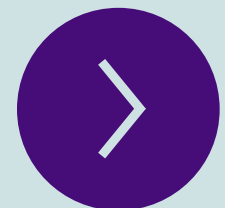


# Content Infrastructure Tech Trends

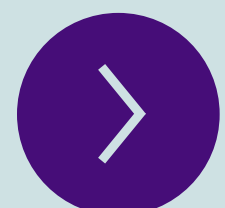
## Connectivity and bandwidth - Native IP infrastructure



Even though the COVID-19 pandemic slowed down major upgrade projects among broadcasters, which usually drive investment in IP networking, the move toward remote production, crew consolidation and cloud computing balanced the adoption of IP in 2021.



At the project level, uncompressed IP projects - being mainly linked to larger greenfield projects - were slightly delayed, while compressed IP projects and public cloud deployments, facilitating remote working and production, were accelerated during the pandemic.



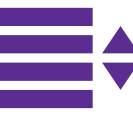
Recently, large facility projects - prioritizing scalability - have resumed and in these projects IP is now considered a default choice, according to the RIST Forum (Reliable Internet Stream Transport protocol society).



*As much as I'd like to not talk about the pandemic, it's definitely changed the **short-to medium-term focus on IP in a central facility to using IP for remote production or cloud production.** So, the trajectory for IP is still growing but it's growing in a **different way to the way it would have.***

*Kieran Kunhyaley - Founder and CEO, Open Broadcast Systems*

Sources: IABM, IBC365



# Content Infrastructure Tech Trends

## Connectivity and bandwidth - Hybrid SDI/IP infrastructure

Hybrid SDI/IP



As media companies still have a lot of legacy equipment in place, a complete switch-over at once would be very expensive and thus many prefer a hybrid approach, allowing them to use both SDI and IP, smoothing the integration of their existing technologies with new IP-based workflows.



Broadcasters who are adding new IP studios/control rooms or building out capacity using IP are likely to maintain their core SDI network due to cost reasons. Also, "tier 2 and 3" operations (i.e., smaller installations and studios) are mostly adopting a hybrid approach, given the financial pressures caused by the pandemic.



This is driving demand for SDI/IP gateways and convergent SDI/IP orchestration systems as well as solutions for 12G-SDI, which offer much more bandwidth than HD-SDI and can handle HDR and deep colour 4K/UHD signals over a single cable.

### Hybrid SDI/IP Approach - Key factors in managing the transition



Costs and existing legacy tech investment



Interoperability between platforms on and off premises



Orchestration tools to manage traditional and IP-based workflows in distributed production architectures

Sources: IABM, IBC365, Nevion, newscaststudio.com

# Content Infrastructure Tech Trends



## Connectivity and bandwidth - Hybrid SDI/IP infrastructure



While the broadcast market is still learning about IP, different standards (e.g., ST 2110) and open specifications, SDI is evolving alongside technology and workflows, supporting the SDI to IP conversion and enabling a hybrid environment. As a result, demand for 12G-SDI solutions (e.g., switchers, servers, routers, signal processing and multiviewers) continues to increase, as many broadcasters still prefer the familiarity, simplicity and lower cost of SDI infrastructures when accommodating 4K/UHD production and preparing for a seamless SDI-to-IP migration in the long term.



Many broadcasters are still lacking in-house expertise to design and maintain IP infrastructure as well as training capabilities, making them less agile in responding to technical issues and system changes. Hence, many end users are now investing in new "plug and play" solutions that combine SDI and IP routing capabilities in a single system. Such solutions provide broadcasters a seamless transition to all-IP infrastructure once they feel ready for it. For example, EVS' MediaInfra Strada - launched in 2021- is a turnkey combi SDI/IP routing solution with access to 24/7 technical support. Partnering with Utah Scientific, EVS can better address live broadcasters still active in the SDI world with multiple routing approaches: native SDI, pure IP and combined turnkey options.

Sources: IABM, thebroadcastbridge.com, IBC365, Utah Scientific



# Content Infrastructure Tech Trends

Connectivity and bandwidth - Hybrid SDI/IP infrastructure

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*Today broadcasters who prefer to keep their traditional SDI infrastructures do so with unease, fearing that their decision will not take them to where they need to go in a year or two. On the other hand, those who choose to deploy an IP-based infrastructure do so with a tightening of the jaw, fully aware of the pain that awaits them when configuring, troubleshooting and paying for their cutting-edge system.*

*Nestor Amaya, VP Solutions Architecture, EVS*



”

*The initial demand for 12G-SDI started with the 2018 Winter Games in South Korea as customers looked to build OB trucks for UHD. At the time, IP was still considered to be in its infancy as the ST 2110 standard was still developing and availability was limited, so customers wanted to stay with something they were familiar with. Recently, the same logic has carried over to local stations, stadiums, and esports as they are updating their technology.*

*Mo Goya, Senior Director Live Media Solutions, Evertz Microsystems*

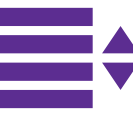


Sources: IABM, thebroadcastbridge.com, IBC365, Utah Scientific



# Content Infrastructure Tech Trends

Connectivity and bandwidth - IP in live production



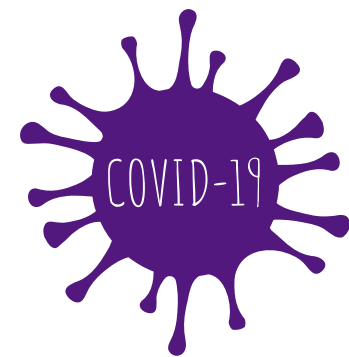
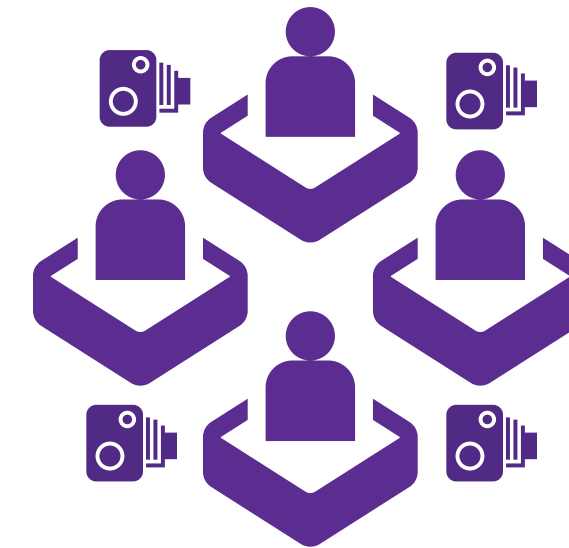
Centralized live production

ST 2110



Decentralized live remote production

HEVC



IMPACT



SMPTE ST 2110

The COVID-19 pandemic reduced live studio-based productions - for which SMPTE ST 2110 was principally designed - decreasing investment in live infrastructure overall with a new focus on remote live and remote scripted infrastructure, making ST 2110 less appealing.

Broadcasters' move to decentralized remote production increased the adoption of the HEVC codec, reflecting the industry's permanent shift toward live video streaming of 4K UHD content.

ST 2110 cannot be used over the internet, because its' multicast technology requires IP networks capable of supporting a minimum of 10Gbps of bandwidth. The Joint Taskforce on Networked Media (JT-NM) is reported to be working on the adaptation of ST 2110 for live remote scenarios.

Sources: IABM, SMPTE, IBC365, tvtechnology.com, Haivision



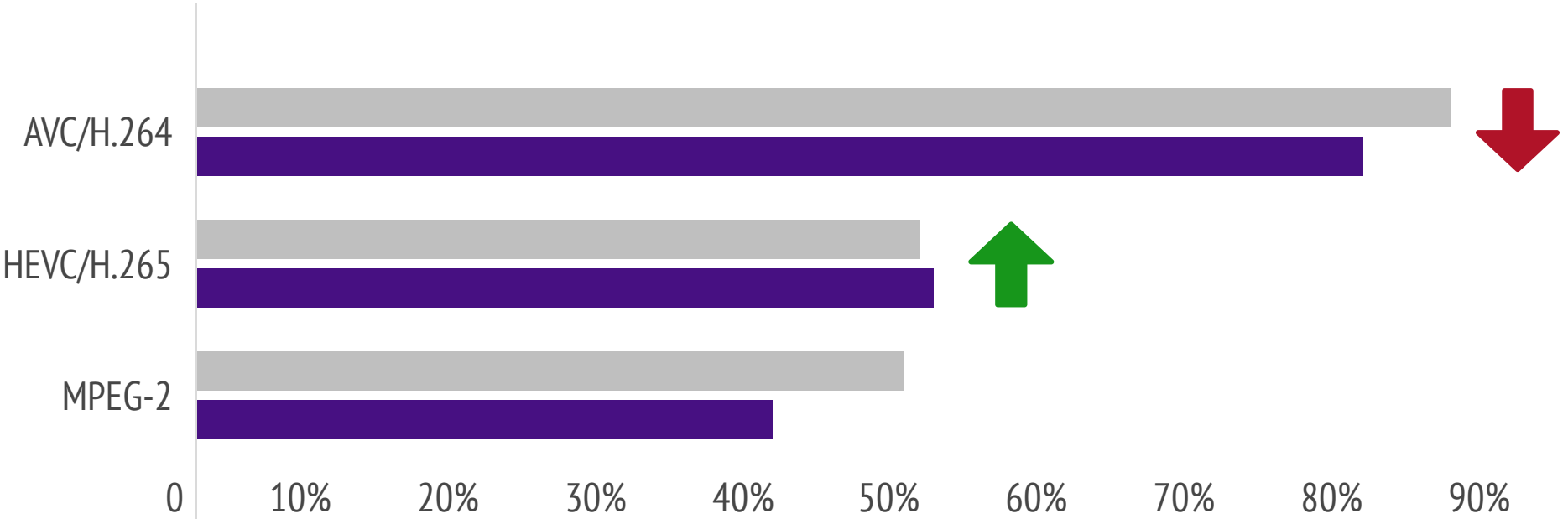


# Content Infrastructure Tech Trends

## Connectivity and bandwidth - IP in live production

Top streaming codecs for live video - Haivision Survey

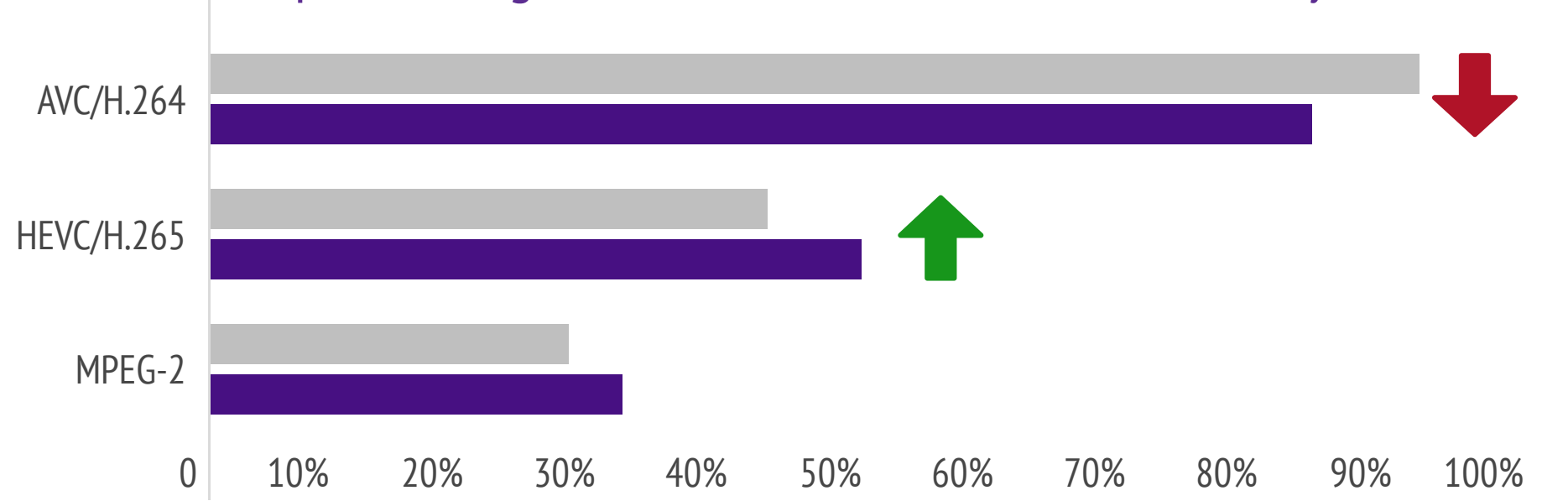
● 2020 ● 2021



COVID-19 Impact on Codecs for Live Content:

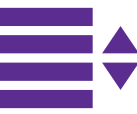
The accelerated transition to DTC in 2021 is speeding up cloud-based deployments and the adoption of IP networking, allowing media companies to do and control live production remotely as well as stream live content with low latency. As a result, demand for the HEVC is increasing, because it enables broadcasters to stream 4K/UHD content at a manageable bitrate over the cloud and IP.

Top streaming codecs for live video - Bitmovin Survey



However, as IP-based technologies for production continue to mature, standards like ST 2110 - designed for live studio production - are expected to become more popular, as they support compressed, lossless codecs like JPEG-XS, which enable streaming 8K over IP. The emergence of game engines, VFX, and virtual studios within mainstream production, as well as increasing demand for interactivity, mean that the network infrastructure needs high bandwidth to handle uncompressed 4K and 8K, boosting demand for ST 2110.

Sources: IABM, Haivision, Bitmovin, tvtechnology.com, SMPTE



# Content Infrastructure Tech Trends

## Connectivity and bandwidth - Implications of migration to IP

### Move to IP Brings Flexibility



**Productivity:** Production resources will increasingly be shared across facilities, locations and teams



**Affordability:** Technology prices are expected to decrease along with an industrywide transition to full IP environments



**Interconnectivity:** Improved interconnectivity and interoperability between vendor solutions is facilitating investments in studio upgrades



### But Requires Time and Investment



**Legacy infrastructure:** For broadcasters with lots of legacy infrastructure in place, a complete switch to all-IP is very costly



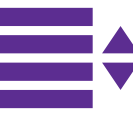
**Lack of skillsets:** Building up IP knowledge and combining it with traditional broadcast engineering skills takes a long time

”

*My assessment of the ‘IP skills’ problem is that we can’t wait to ‘find’ these people – we need to **build** them. The reality is that a lot of the talent we want has no knowledge **our industry even exists.***

*Cassidy Phillips, SMPTE Section Manager &  
VP of Networking Solutions Architect, Imagine Communications*

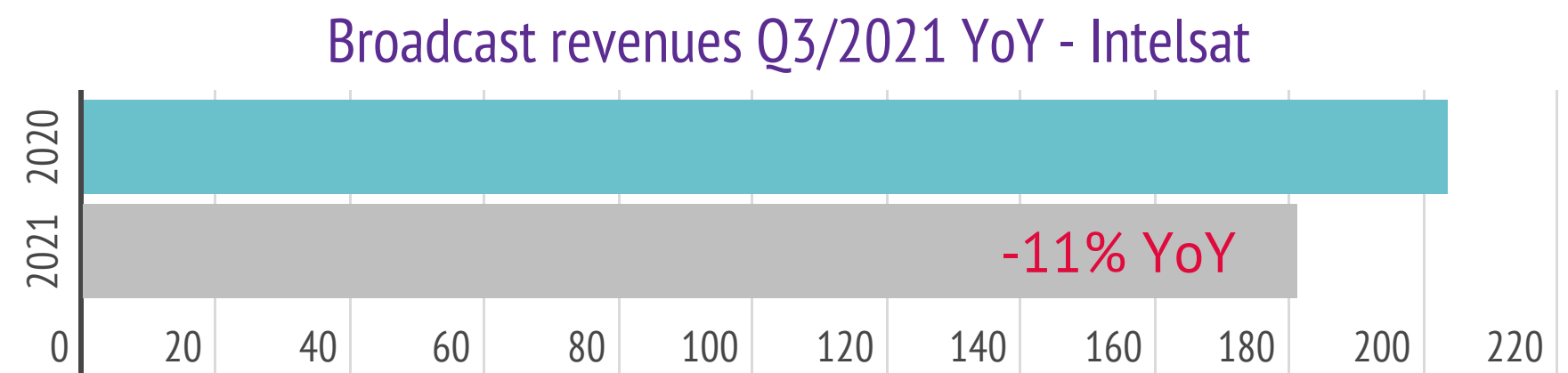
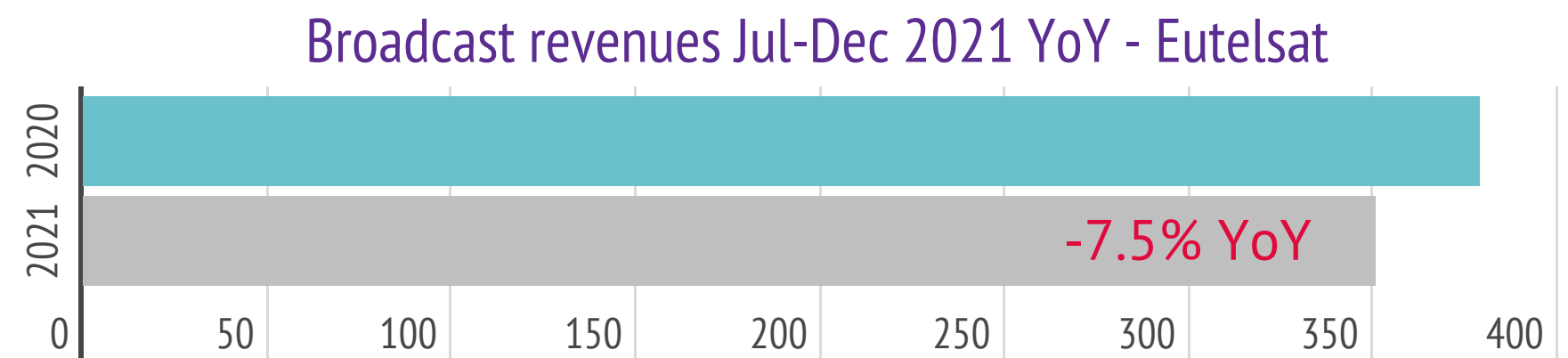
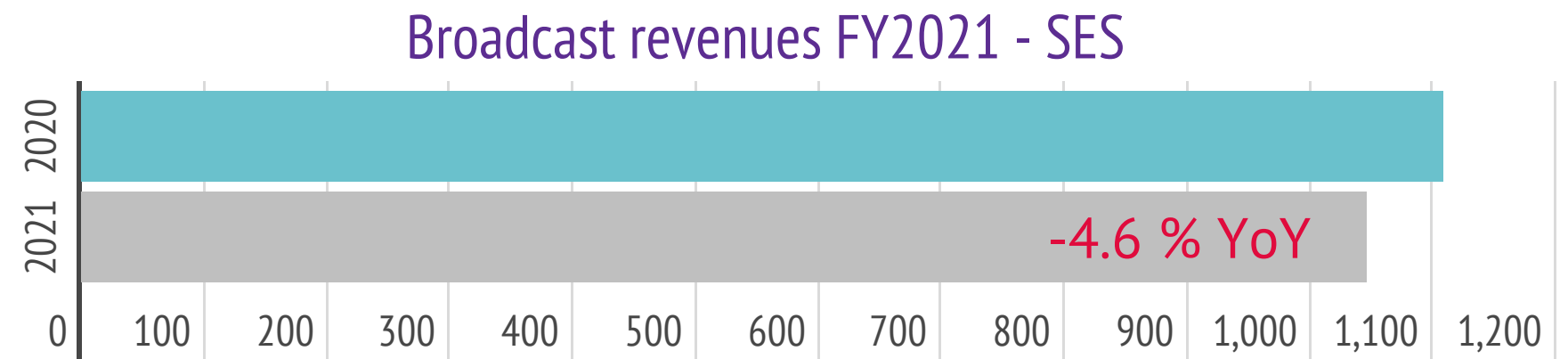
Sources: IABM, IBC365, live-production.tv, tvtechnology.com



# Content Infrastructure Tech Trends

## Access connectivity - Satellite

The COVID-19 pandemic continued to depress the broadcast revenues of major satellite operators. While their media revenues continued to fall, many operators consolidated their operations and focused on other business segments such as commercial aviation (e.g., in-flight connectivity solutions) and the commercial space industry. However, in 2022, satellite operators expect a slight recovery of their media businesses, thanks to the increasing demand for broadband services in Africa and other emerging markets. At the same time, mobile connectivity sales are picking up, reflecting the fragmentation of viewing - and streaming - across multiple devices.



Sources: IABM, Company Filings. Note: Intelsat figures Q3 YoY revenues

# Content Infrastructure Tech Trends



## Access connectivity - Satellite



Along with a mass migration toward IP-based content streaming services - accelerated by the COVID-19-pandemic - broadcasters using traditional connectivity methods like satellite, cable and fiber are facing several challenges of competitiveness such as latency and contractual inflexibility, causing a lack of agility and flexibility to scale operations up and down.



The reallocation of the C-Band spectrum to give space for commercial 5G network rollouts is causing long-term pressure for the B2B satellite industry, forcing broadcasters to explore alternative transport methods for content delivery as the amount of available bandwidth decreases and prices increase.



Many broadcasters moving away from satellite delivery have the delivery cost as a key motivation: satellite and transponder time as well as running the whole infrastructure are very expensive, while satellite transport contracts terms - being based on long term reservations of bandwidth and "use it or lose it" commitments - are rigid, often leaving broadcasters to pay for unused bookings.

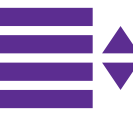
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*The decline in media [revenue] was primarily driven by a planned service migration by a specific customer from Intelsat's network to the **customer's own network assets**. Other factors impacting revenue were **terminations and non-renewals** reflecting industry trends.*

*Intelsat Q3/2021 Quarterly Report*



Sources: IABM, Company Filings, newscaststudio.com, m2amedia.tv, Eutelsat

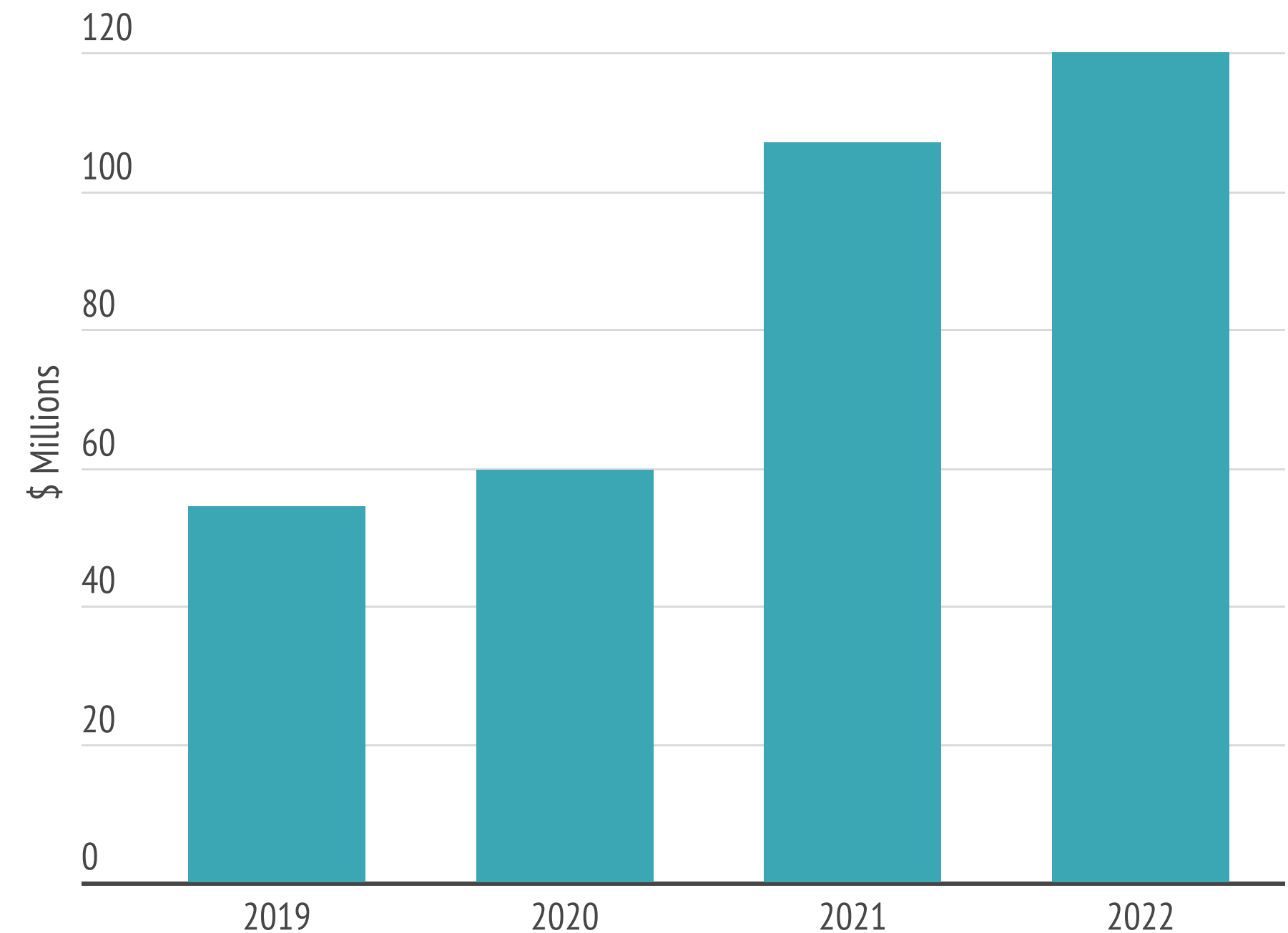


# Content Infrastructure Tech Trends

## Access connectivity - Mobile

The move to decentralized remote production models has translated into increasing investment in mobile connectivity technology. In news, for example, this has driven an increasing use of bonded cellular technology and mobile transmission apps such as Dejero's to transport content from mobile phones to studios or central content repositories. Dejero said they recorded ten times the usual number of live streams from LivePlus apps in April 2020 right after the outbreak of the COVID-19 pandemic. A similar trend is going on in sports which, despite the general shutdown, has had to enable remote working in a way not seen before in the industry, increasing demand for mobile connectivity resources. This trend is also consistent with a focus on shorter content lifecycles.

### Cumulative Funding Raised by Dejero



Sources: IABM, Company Filings



# Content Infrastructure Tech Trends

## Inter-Facility Connectivity - Internet protocols



Media companies' shift to remote production and live streaming during the pandemic boosted the use of "internet-ready", video over public IP protocols like SRT (Secure Reliable Transport) and RIST (Reliable Internet Stream Transport), which are designed for low latency contribution over IP and the public internet. This significantly reduces networking costs, because these protocols are specifically designed for internet delivery and to provide low latency over variable performance networks - enabling higher quality of live and remote production. The adoption of SRT and RIST thus means extra investment in encoders.

Protocols like SRT and RIST offer live OTT productions cost savings by simplifying and reducing the data load without impacting the image quality. Simultaneously, both protocols allow a high-quality codec (like HEVC, VVC, AV1) to be used for production - this is important because video quality is maintained throughout the supply chain when re-encoded and re-transcoded for the delivery to consumer devices. As media companies continue to invest in immersive and interactive content, low latency streaming applications and solutions will be in high demand, particularly for gaming, betting, online video games and second-screen experiences.



**Remote production:** Al Jazeera is already using SRT for low-latency content acquisition and distribution globally. After having adopted the SRT protocol, the broadcaster can transport breaking news from the field to remote studios for syndication - this reduces costs and technical issues related to satellite and MPLS networks.



**Live sports:** ESPN currently uses SRT to broadcast live sports events from universities across the US, which has eliminated its need for satellite uplinks and thus has reduced costs significantly - SRT has enabled ESPN to "do more with less". In addition, by using SRT ESPN can offer games and other interactive content on its national platform.

Sources: IABM, wowza.com, RIST Forum

# Content Infrastructure Tech Trends



## Inter-Facility Connectivity - Contribution/distribution encoders

Live contribution encoding - Performance-cost trade-off

Legend: Latency (teal), Quality (grey), Network cost (purple)



**Scenario 1:** Video contribution with high quality and low latency requires the most network bandwidth and is the most expensive option, often utilizing private networks and hardware-based encoding (processing codecs like HEVC) to maximize reliability and performance. Hence, it is mainly used for premium content.

**Scenario 2:** Video contribution with low quality and low latency is a cheaper option, as lower-quality codecs are used and contributions streams require lower bandwidth network connections.

**Scenario 3:** The use of SRT and RIST - the protocols specifically designed for internet distribution - enables encoders to deliver high quality and low latency streams through the internet, enabling very high quality live production for a wide range of new venues. This significantly reduces networking costs, because SRT and RIST are "internet ready" by design.

Sources: IABM, thebroadcastbridge.com, tvbeurope.com, RIST Forum, OBS Studio

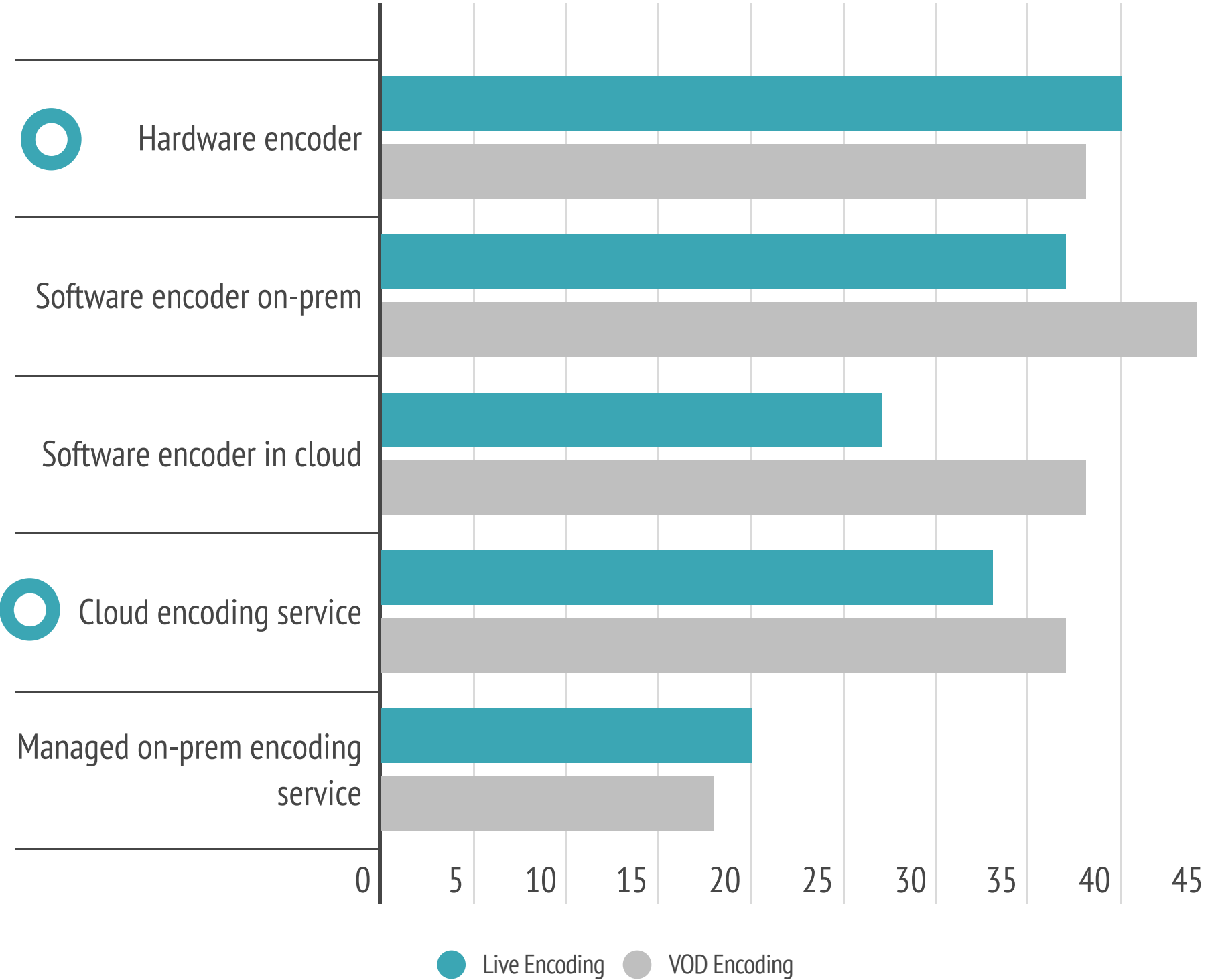


# Content Infrastructure Tech Trends



## Inter-Facility Connectivity - Contribution/distribution encoders - Encoding location

Most preferred location of encoding - Bitmovin 2021 Survey



”

*Moving your video encoding/transcoding to the cloud trades all of the [in-house] costs for a monthly fee. It could be argued that, once you've got the server farm up and running, it might cost you less to be encoding/transcoding in-house than paying a third-party to do it for you. But that equipment has a limited lifespan, and the base of formats it has to serve keep changing and expanding. So you won't escape more CAPEX for long.*

*Eric Quanstrom, COO, Sorenson Media Inc*

Sources: IABM, streamingmediaglobal.com, Bitmovin



# Content Infrastructure Tech Trends

## Inter-Facility Connectivity - Contribution/distribution encoders - 5G for live contribution

**Ultra-low latency video delivery:** As seen during the 2022 Super Bowl, Verizon's 5G SuperStadium in-stadium live stream was the only service providing an ultra-low latency video delivery, while other live OTT streaming platforms had a latency of over one minute compared to a traditional live broadcast. This exemplifies the significant benefit of 5G in video contribution.

**Scalability & Democratization:** In terms of scalability, 5G has the potential to provide approximately 10 times more bandwidth per base station, and it can accommodate many more base stations within the same area, allowing bandwidth to be offered in the hot spots such as concerts and live sports events. 5G will also allow advanced streaming capabilities beyond the home enabling mobile users without a Wi-Fi connection to enjoy immersive and interactive experiences, democratizing video.

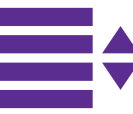
**Challenges:** While video contribution via 5G network is a promising opportunity especially for live sports, there are several barriers to deployment. Several test programs are already looking at these issues including wired and wireless multi-camera synchronization brought about by encoding/decoding latencies, slicing the network to meet broadcast standard SLAs and to assess the latest contribution capabilities.

”

*The two big challenges are **encoding and uplink performance**. Those are the areas that 5G has to adapt to and the telcos have to address.*

*Grant Totten, Head of Media & Emerging Platforms,  
Al Jazeera*

Sources: IABM, IBC365, Harmonic, wowza.com,



# Content Infrastructure Tech Trends

## Inter-Facility Connectivity - Contribution/distribution encoders - 5G for live contribution

As media businesses move to the cloud, their possibilities to take advantage of 5G in video transport improve significantly - 5G Edge Cloud enables caching video content locally by using Mobile Edge Computing (MEC) in a 5G environment. For example, this would enable cloud resource caching to be used on-demand in stadiums using 5G.

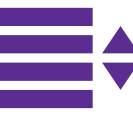
Verizon - which has deployed 5G mmWave networks in 25 NFL stadiums in the US to allow fans to see several unique camera angles and to enjoy AR games and other interactive services - is also taking advantage of MEC infrastructure paired with its low latency 5G Ultra Wideband network to provide fans with real-time statistics.

Many cloud companies and MNCs have already formed partnerships to integrate cloud technology at the edge of the 5G network and this trend is likely going to strengthen as the commercial rollout of 5G networks expands in several markets. For example, Verizon and AWS have already partnered to introduce Verizon 5G Edge with AWS Wavelength around the 2022 Super Bowl. AWS Wavelength Zones enables producers to get the video feed into the cloud in near real-time to process it and then send it back to the fans - in the stadium and at home - over the 5G network.

### Mobile Edge Computing (MEC) in Live Broadcasting



Sources: IABM, IBC365, GSMA, fastcompany.com, Verizon, Zixi



# Content Infrastructure Tech Trends

## Inter-Facility Connectivity - Mobile edge computing with 5G

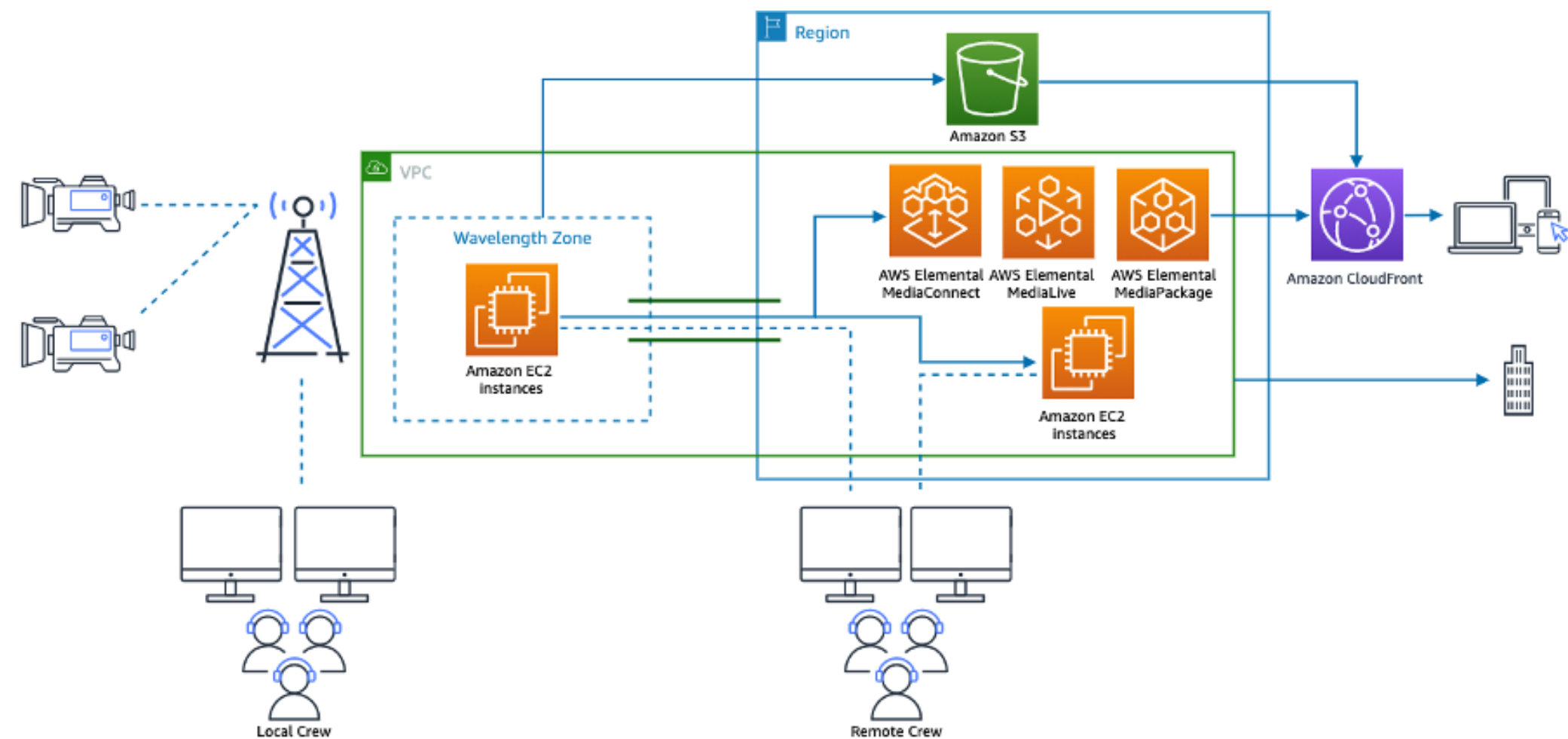
In December 2019, AWS introduced a media-specific AWS Wavelength solution, which embeds AWS compute and storage services at the edge of telcos' 5G networks, allowing media companies to build applications like game and live video streaming and AR/VR for mobile video viewers with very low latency. In December 2021, the San Francisco Opera delivered a real-time remote opera performance using AWS Wavelength Zones on Verizon 5G Ultra Wideband connecting/ synchronizing artists' performances, who were physically singing in Las Vegas and San Francisco.



*Coaching with teachers in another city, workshopping a new piece with singers across the country, and jamming together for fun with friends—this technology opens up amazing flexibility for music making and it's a flexibility that's here to stay.*

*Matthew Shilvock, General Director, San Francisco Opera*

### AWS Wavelength - Ultra low latency streaming and gaming via 5G



Sources: IABM, AWS Blog, Verizon



# Content Infrastructure Tech Trends



## Inter-Facility Connectivity - Mobile edge computing with 5G

### **Bloomberg Media tests 5G & mobile edge computing with AWS, Verizon and Zixi**

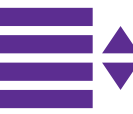
In February 2022, Bloomberg Media, AWS, Verizon and Zixi revealed that they are working together to test 5G and mobile edge computing in the production, delivery and consumption of global business news. In the project, Bloomberg Media aims at packaging and delivering live 4K/UHD content by using Verizon 5G Edge with AWS Wavelength, a real-time cloud computing platform, which brings AWS' compute and storage services to the edge of Verizon's wireless network. Being coupled with Zixi's SDVP and ZEN Master control plane - which processes the video into multiple streams for broadcast across different platforms - a high quality broadcast can be maintained. Zixi's software simplifies the networking between hosted software services on 5G Edge with AWS Wavelength and the end user's device - with ultra-low latency. The project partners also plan to test streaming Bloomberg TV+ 4K/UHD content direct to consumers' 5G-connected devices, which enables viewers to access interactive, richer content on the go.

”

*This proof of concept trial combines Verizon's 5G and mobile edge computing capabilities with Bloomberg TV+ premium 4K UHD content to create a modern streaming news experience with the potential for true industry disruption.*

**Roman Mackiewicz**  
**CIO, Bloomberg Media**

Sources: IABM, AWS, Verizon, martechseries.com



# Content Infrastructure Tech Trends

## Video Interfacing & Conversion



The COVID-19 pandemic shut down productions and live events and caused a sudden lack of new live content resulting in broadcasters using old SDR footage from their old catalogs. At the same time, demand for HDR content and other new image formats peaked dramatically. For media companies - having a mixed catalog of old SDR and new HDR content - this meant that in order to keep viewers engaged and to monetize their existing SDR content library, they had to convert it to HDR.

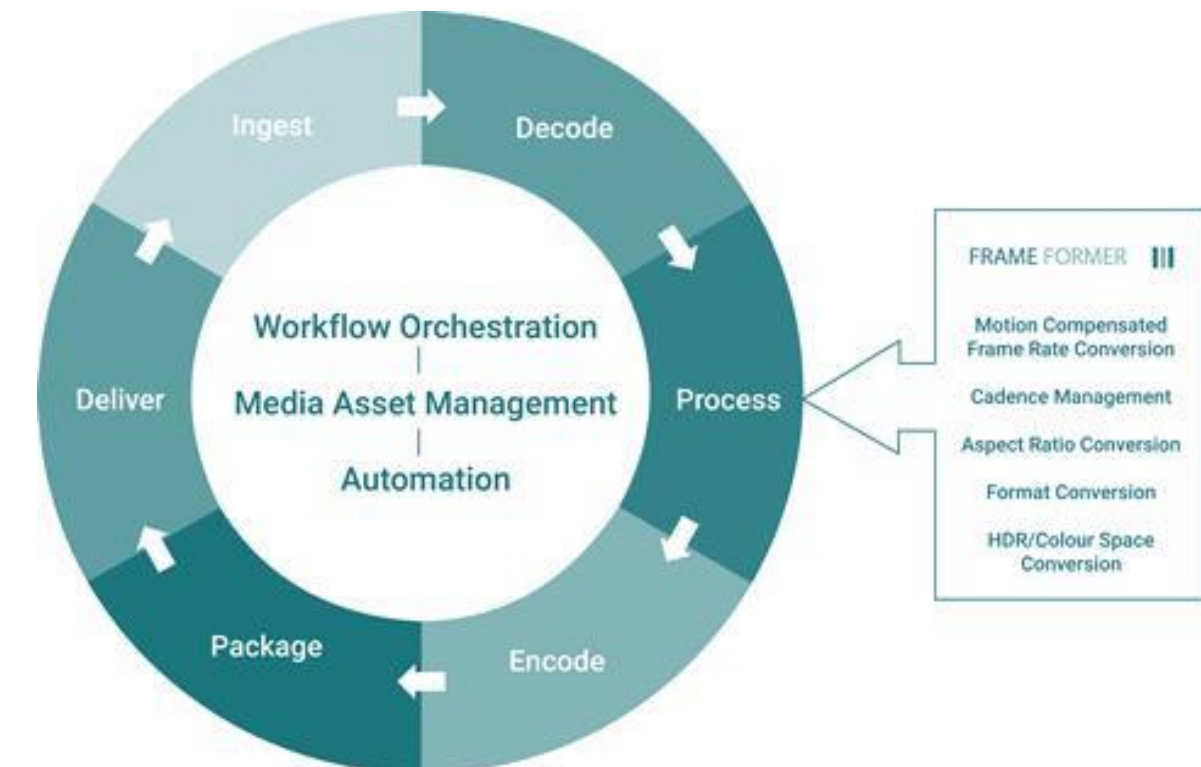


As media companies move to the cloud, they are increasingly taking advantage of cloud-based conversion solutions. For example, in 2021, InSync introduced PixFormer, an API integrated software-based conversion solution for SDR-to-HDR conversions, which can run on-prem or in any cloud environment. PixFormer complements InSync's FrameFormer Link Live conversion engine, which supports live conversion of all formats up to 4K/UHD, which is also available with AWS Elemental MediaConvert, a file-based media transcoding service.



In terms of emerging conversion methods, an increasingly preferred SDR-to-HDR conversion technique is called "inverse-tone mapping" (or up-mapping), which creates "HDR look" for the SDR clips, which can be blended into an HDR production or platform. Another interesting conversion method using AI and deep learning is called "Super Resolution" (SR), a process of transforming, sharpening and upscaling low resolution video into high resolution (e.g., 480p video to 4K UHD). For example, AWS offers a DL-based SR tool.

### Cloud-based conversion tools - SDR-to-HDR (InSync)



### AI-based conversion tools - Super Resolution (AWS)



Sources: IABM, AWS, IBC365, Bitmovin



# Content Infrastructure Tech Trends

## File Transfer & Delivery

### COVID-19 Impact on Video Transport

The COVID-19 pandemic led to the decentralization of operations and the movement of HD/UHD content over unmanaged internet and private IP networks to allow for distributed production models.

The move to decentralized operations increased spending on internet transport technologies such as direct connect and file delivery/acceleration in 2021. File acceleration technology has significantly facilitated remote productions to transfer HDR and 4K/UHD footage over standard IP networks, eliminating latency.

Demand for file acceleration solutions provided by suppliers like IBM Aspera and Signiant has increased significantly over the past two years; in 2021, Signiant reported that the volume of data its software moves monthly to and from the cloud had grown by 514% since NAB 2019.

### Growth Drivers of File Acceleration

Cloud ingest applications driven by the streaming boom

Move to remote work and production accelerated by the pandemic

Increasing use of multi-cloud and best-of-breed services offered by different cloud providers

### Time to Transfer 1 HR of HD Content (1 Gbps)

	Transmission Control Protocol (TCP)	Signiant
LA subway	1:28	0:03
LA to NY	5:35	0:03
LA to London	10:59	0:03
LA to Singapore	21:05	0:03

Sources: IABM, tvtechnology.com, Signiant



# Content Storage Tech Trends



# Content Storage Tech Trends

## On-premise storage - Status quo



The COVID-19 pandemic accelerated the adoption of cloud storage, decreasing demand for local, on-premise solutions. However, for many broadcasters, it will still take some years to transfer their on-premise repositories into the cloud - which will also cost a significant amount of money - making on-prem storage a critical part of hybrid storage strategies in the short- and mid-term.

On-premise storage can also be a cost-efficient solution in the short- and medium-term, as existing local storage systems can also store massive amounts of data for a relatively low cost - until the legacy equipment has to be replaced.

New technologies from vendors also enable a cost-effective co-existence of on-prem systems and new cloud-based workflows. For example, software vendors like Telestream offer transitory solutions that enable media companies to make on-prem and cloud storage systems work seamlessly together. However, in the long-term, it seems that on-prem storage will give room to the cloud - permanently.

”

*The **cloud** has capabilities that on-prem will never have – like the fact that it’s everywhere, and that beyond **scalability** it has the ability to **facilitate change** even by orders of magnitude in an instant – in a way that a physical installation never could.*

*Stephen Tallamy, CTO, EditShare*

Sources: IABM, IBC365, tvtechnology.com

# Content Storage Tech Trends



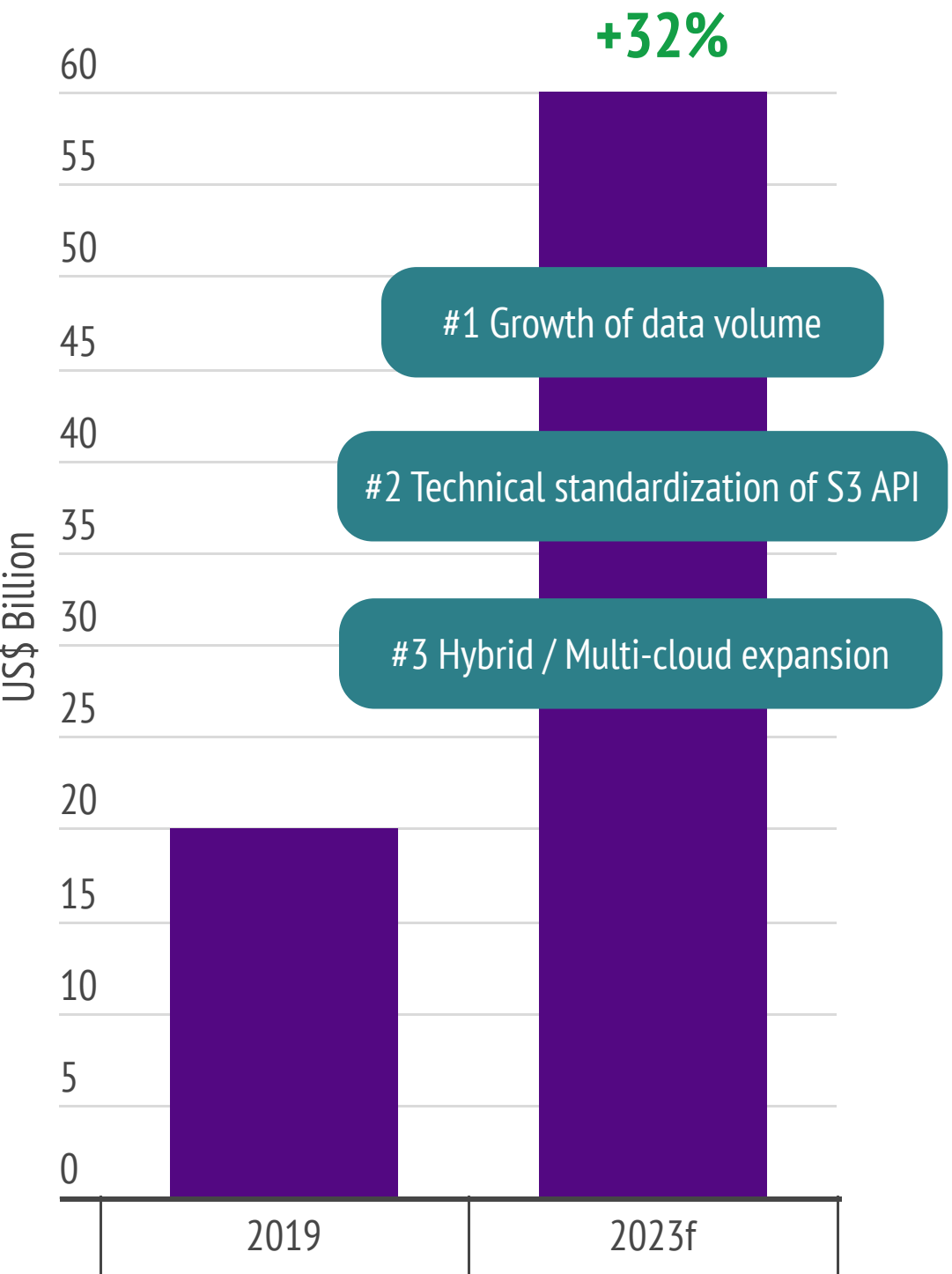
## Cloud Storage - Drivers for adoption

The COVID-19 pandemic significantly accelerated broadcasters' move to the cloud and cloud storage, enabling greater flexibility, scalability, accessibility and cost-efficiency when the need for collaborative and remote work peaked dramatically. In the long term, major drivers for cloud storage adoption include the gradual cost reduction of both the actual storage itself and the bandwidth required to use it.

Media companies' move toward remote decentralized productions have made a transfer to the public cloud more attractive due to its greater accessibility (anywhere) - it is increasingly serving as the landing zone for content, when media companies need to process content and respond to demand peaks quickly - globally. Another key driver for the public cloud storage relates to a wide range interoperable vendor applications, solutions and tools that it offers.

Using cloud storage also gives greater flexibility for viewers to choose when and how they want to watch content and whether want to record and store it, improving UX. This can be seen in how library storage and time-shifting consumption traffic have increased among broadcasters. Also, viewers' increasing demand for 4K/UHD, HDR and immersive VR/AR content means that more digital content compression (e.g., HEVC, AV1) will be needed, favoring cloud storage.

### Cloud Storage Services Revenue Globally



Sources: IABM, IBC365, IDC, Cloudian

# Content Storage Tech Trends

## Cloud storage - Key trends



### Trend 1: Expansion of hybrid and multi-cloud infrastructure for storage

The COVID-19 pandemic dramatically accelerated media companies' demand for cloud storage, particularly hybrid cloud, given the relatively high amount of "technical debt" that many broadcasters have with their existing infrastructure, making a partial on-prem storage approach financially viable as an interim solution. At the same time, many media businesses increasingly prefer a multi-cloud approach to avoid vendor lock-ins or growth limitations of working with only one cloud provider, which cannot specialize across a wide range of applications, storage and computing needs.

### Trend 2: Blurring of lines between different types of storage

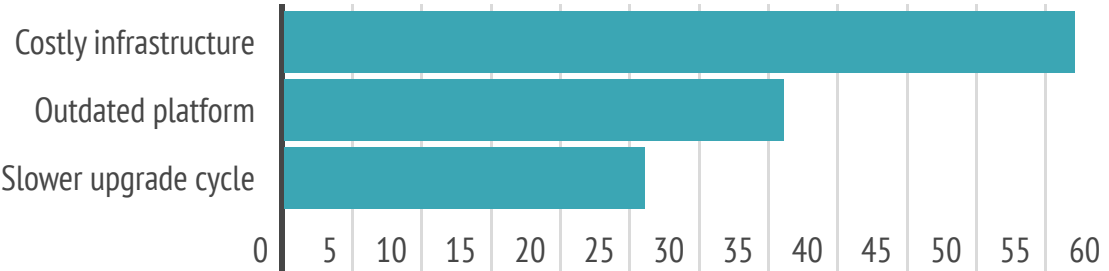
Media companies - increasingly taking a holistic approach to determining their storage arrangements - are now looking at tech solutions enabling a smoother use of storage tiering and storage migration options, further improving their flexibility when moving to the cloud.



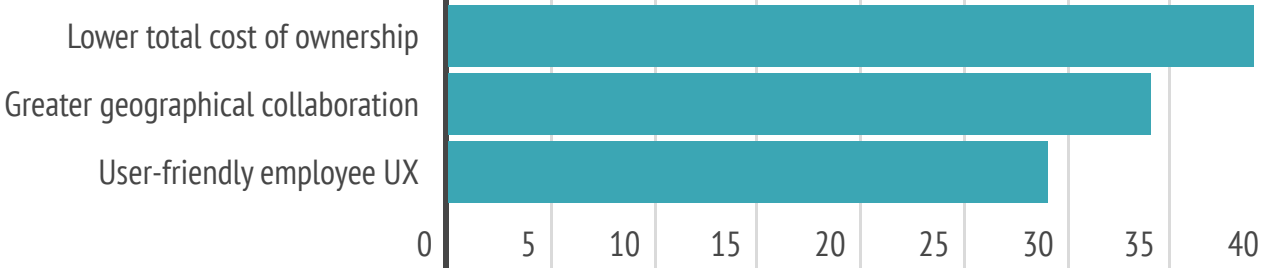
*The reasons why customers are moving – or considering moving – to the cloud are mostly related to **flexibility** in their operations, **lower TCO** [total cost of ownership] when all the factors (real estate, electricity, AC and maintenance) are considered, and the **predictability** of the financial **cost of operations**, tied to an **Opex financial model**.*

*Raul Alba, Director of Solutions Marketing, Avid*

#### On-premise pain points

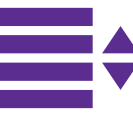


#### Cloud Adoption Advantages



Sources: IABM, IBC365, Atos





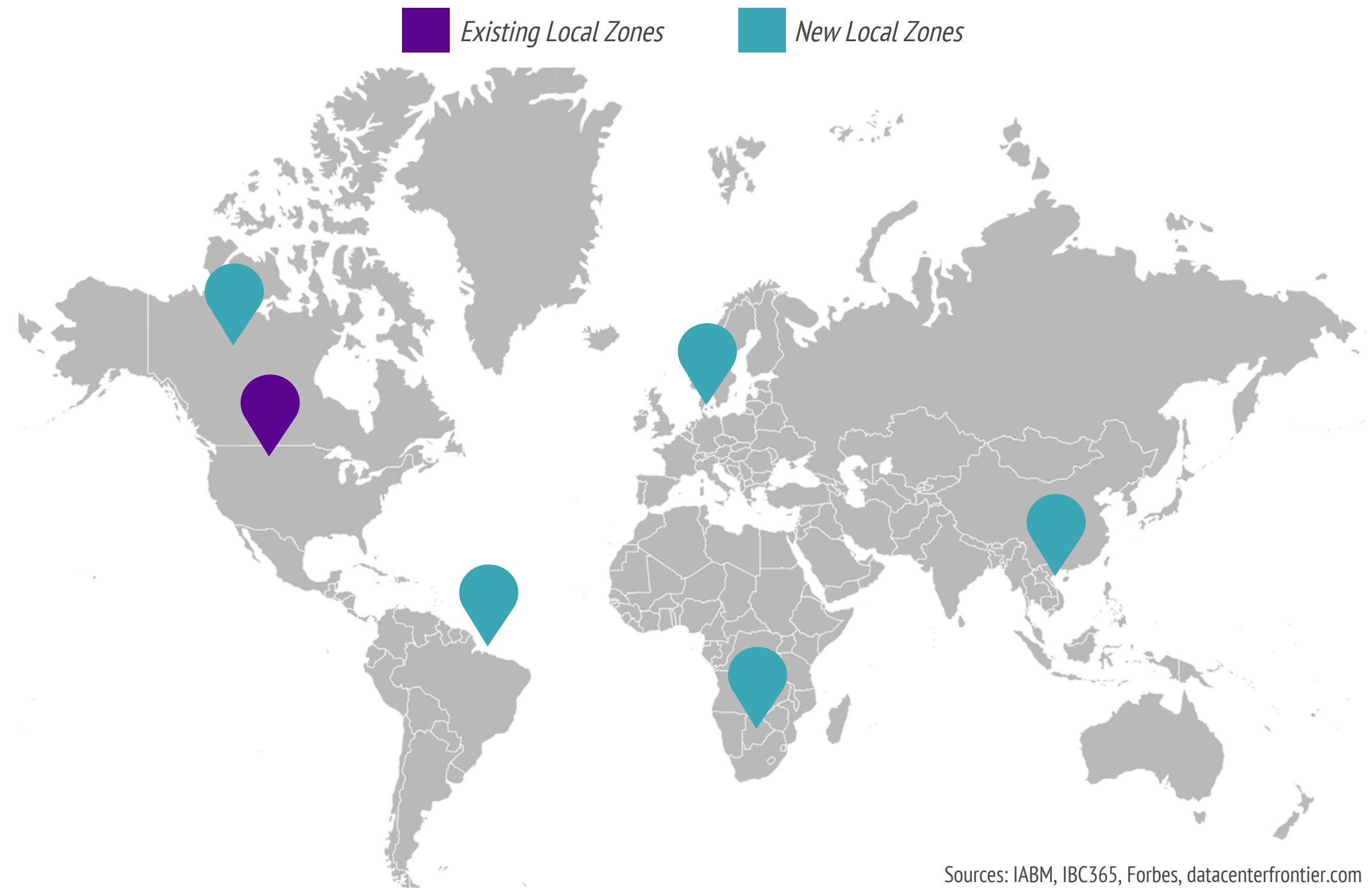
# Content Storage Tech Trends

## Cloud storage - Move to the edge

Media businesses' move toward decentralized remote productions is driving investment in edge computing and cloud storage, which bring new efficiencies to TV and film production through shared access and virtual management of huge video files. Edge computing brings cloud resources closer to decentralized (post-) production teams, enabling low latency access to virtual workstations, especially benefitting artists creating visual effects, immersive content and games of very large file size.

For example, AWS announced in February 2022 that it will expand its edge computing infrastructure - Local Zones - to 32 cities around the world. At the same time, Akamai - a major player in edge computing - announced its acquisition of Linode, an edge computing company, for US\$900 million, which will expand Akamai's distributed global network to edge. In the media space, early adopters of edge computing and Local Zones include big streaming services like Netflix and a cluster of gaming companies.

### Expansion of Edge Computing Infrastructure - AWS Local Zones



Sources: IABM, IBC365, Forbes, datacenterfrontier.com



# Content Storage Tech Trends



## Cloud storage - Move to the edge

The COVID-19 pandemic accelerated media companies' investment in interactivity and engaging, immersive content featuring AR, VR, and mixed reality. At the same time, several tech companies are preparing for the metaverse to share experiences combining gaming, entertainment, e-commerce. AWS' new Local Zones enable AWS' customers to deploy low-latency applications in new markets and offer cloud-based services in new places.

”

In order to provide a good working experience for our artists, they need **low latency** access to their **virtual workstations**. We are excited about the expansion of AWS Local Zones globally, which brings **cloud resources closer to creators**, allowing artists to get to work anywhere in the world and create without boundaries.

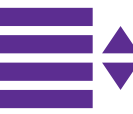
*Stephen Kowalski, Director of Digital Production Infrastructure Engineering,  
Netflix*

”

With AWS Local Zones, we're able to deploy resources in **more geographic locations** across our multiple studios. This has been integral to the success of our crew members who are able to **access cloud studio servers** at such **low latency** that it almost feels like they're using a computer locally.

*Ryan Thompson, Co-Founder & CPO, Esports Engine*

Sources: IABM, AWS, datacenterfrontier.com

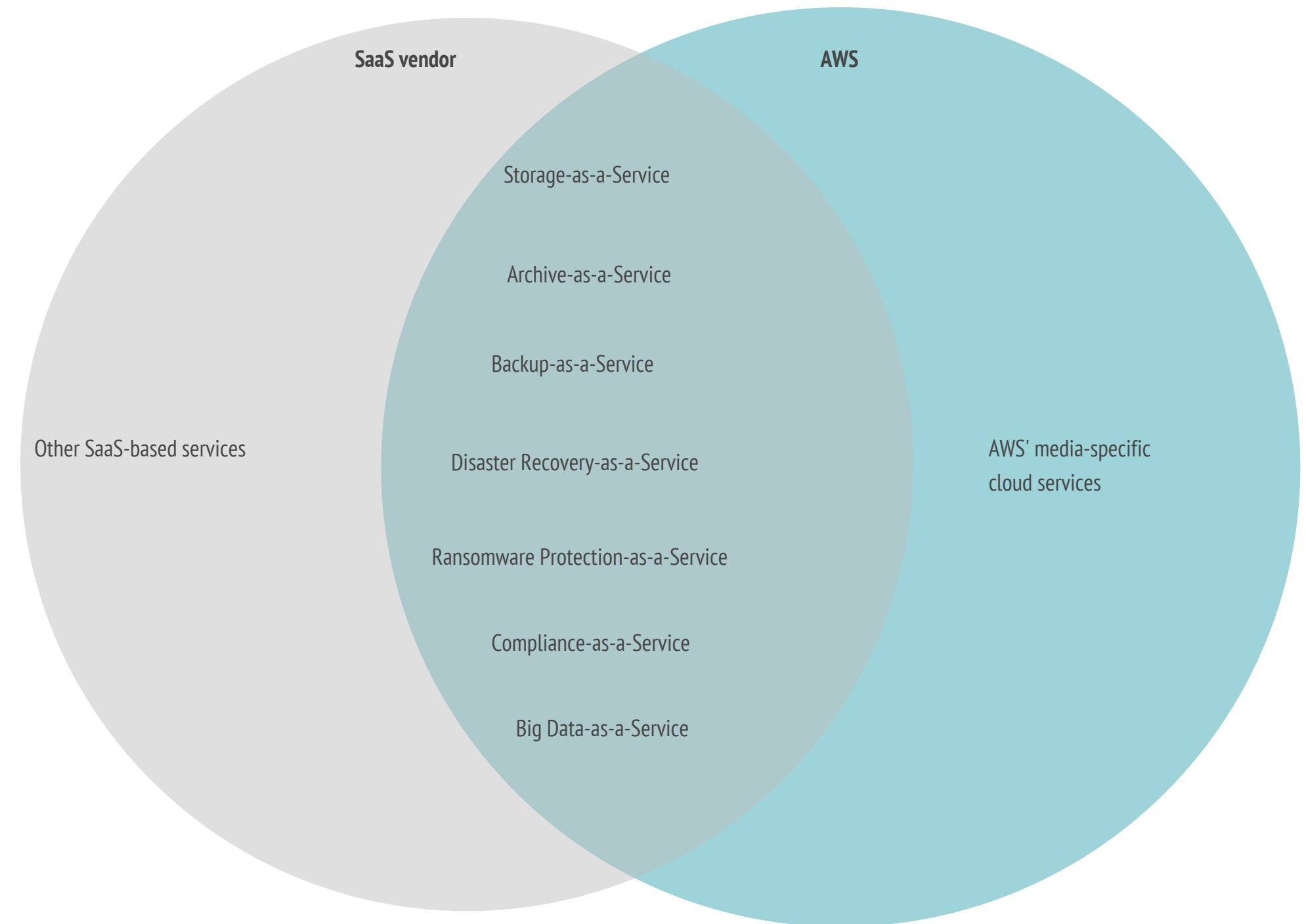


# Content Storage Tech Trends

## Cloud storage - Hyperscalers

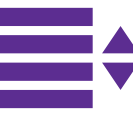
Big vendors - or hyperscalers - like AWS, Microsoft Azure and Google Cloud Platform are introducing new, media-specific, managed cloud services to simplify the transition. For example, AWS launched OpenZFS and introduced NetApp's Cloud Volumes ONTAP service on its platform in 2020, which enable a "close approximation of on-premise file systems to move existing workloads to the cloud and connect with other AWS services". Hyperscalers are also expanding their backup, disaster recovery and SAN services, targeting massive legacy databases of media businesses. These new services improve availability of data, while they reduce the complexity between hot and cold storage pricing tiers.

### Hyperscalers entering traditional SaaS vendors' market niche



Sources: IABM, IBC365, AWS, techtarget.com, itprotoday.com

# Content Storage Tech Trends



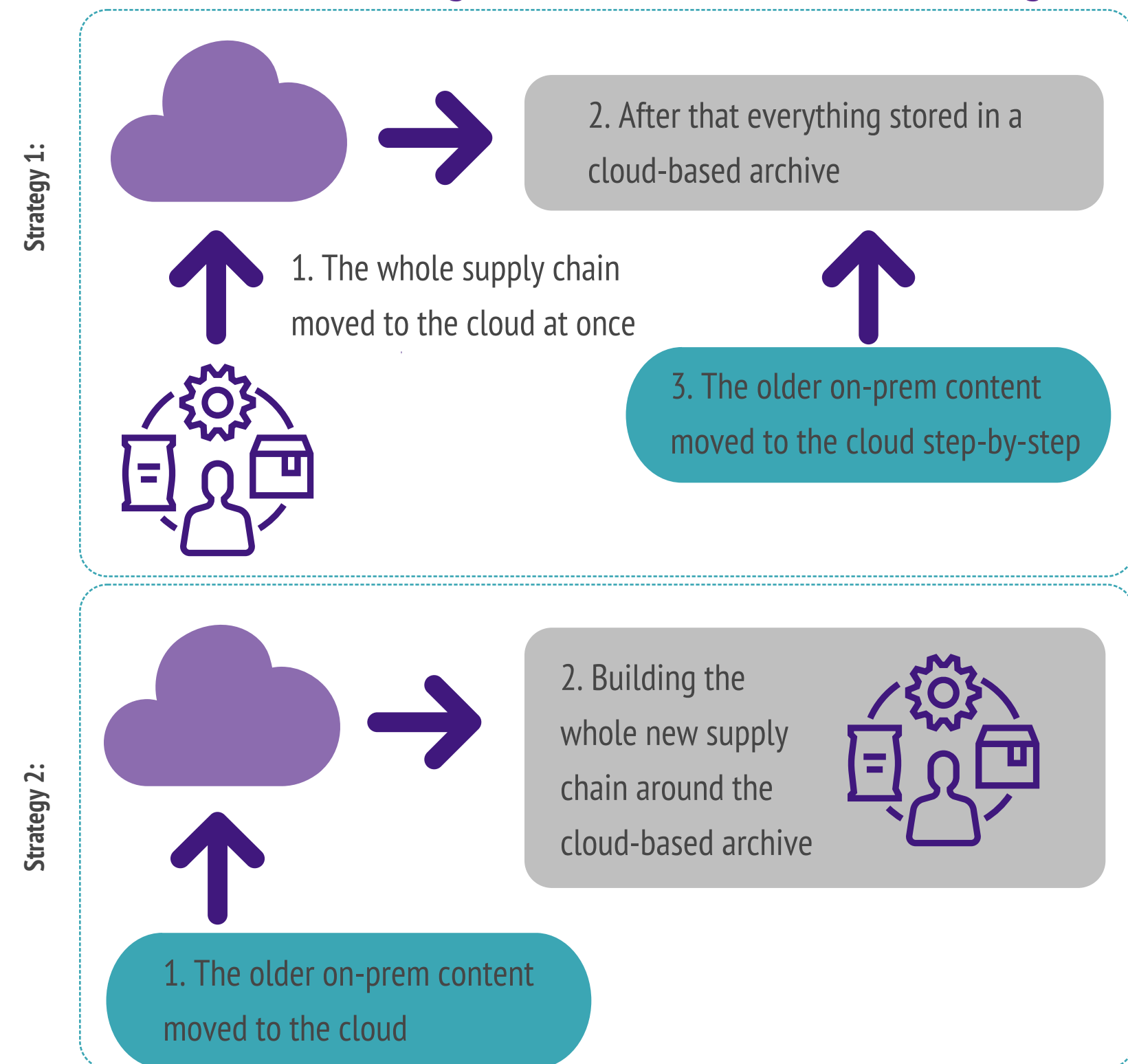
## Cloud archive storage

The COVID-19 pandemic accelerated media companies' investment in cloud-based archiving, when they had to respond to an explosive demand for content, while many live events got cancelled and the lockdown prevented production teams from physically access on-premise archives.

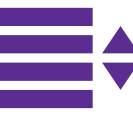
The shift to remote production and the expansion of streaming services have pushed media companies to adopt a more structured approach to archiving by making at least some part of their content library easily and remotely accessible - and better monetizable - through a top tier cloud archive, while older programs/material may stay on-prem until the whole supply chain is moved to the cloud.

Many broadcasters still prefer a hybrid model instead of a 'pure' cloud model for archiving, as they fear that cloud vendors will increase their prices and change their policies, making the storage of content (particularly in 4K, HDR and 8K) unpredictably expensive. However, in the long-term companies seem to be preparing for cloud-centric archiving, as their overall operations move to the cloud.

### Two common strategies toward cloud-centric archiving:



Sources: IABM, IBC365



# Content Storage Tech Trends

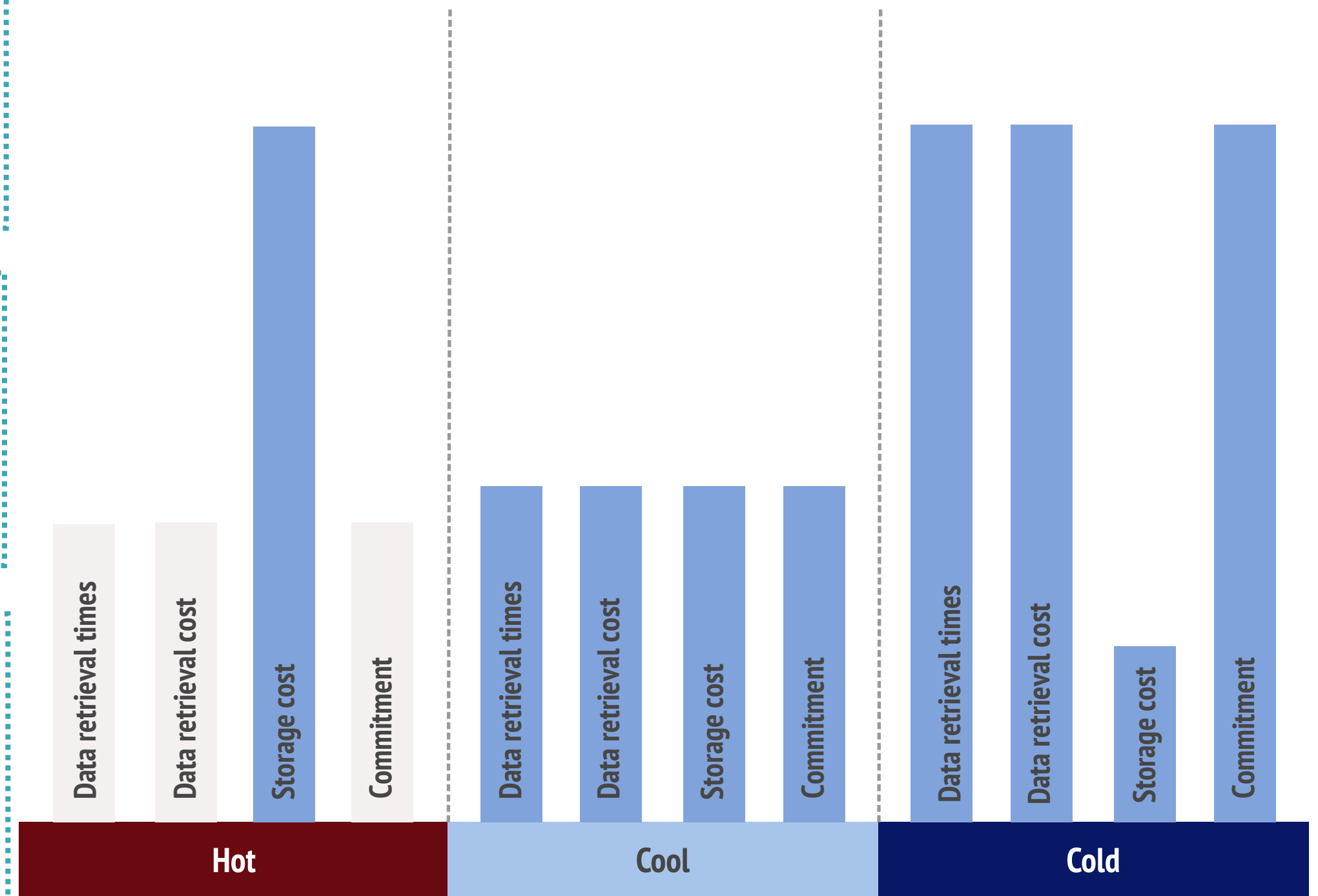
## Cloud tier types

The move to DTC business models and decentralized remote productions require better accessibility and discoverability of content, translating into an increasing need for dynamic, active (AI-supported) storage with lower latencies to retrieve data and to reduce application response times.

Hence, big public cloud vendors are expanding their free tier services and making data retrieval cheaper and faster, blurring the line between hot and cold storage. For example, in 2021, AWS launched Amazon S3 Glacier Instant Retrieval - targeted for "news media assets".

The next-generation unstructured data management systems are soon expected to become a game changer in storage pricing, because they can discover, map and replicate data without having to move it between the tiers - changing storage purchase decisions.

Cloud Tier Types - Comparison:

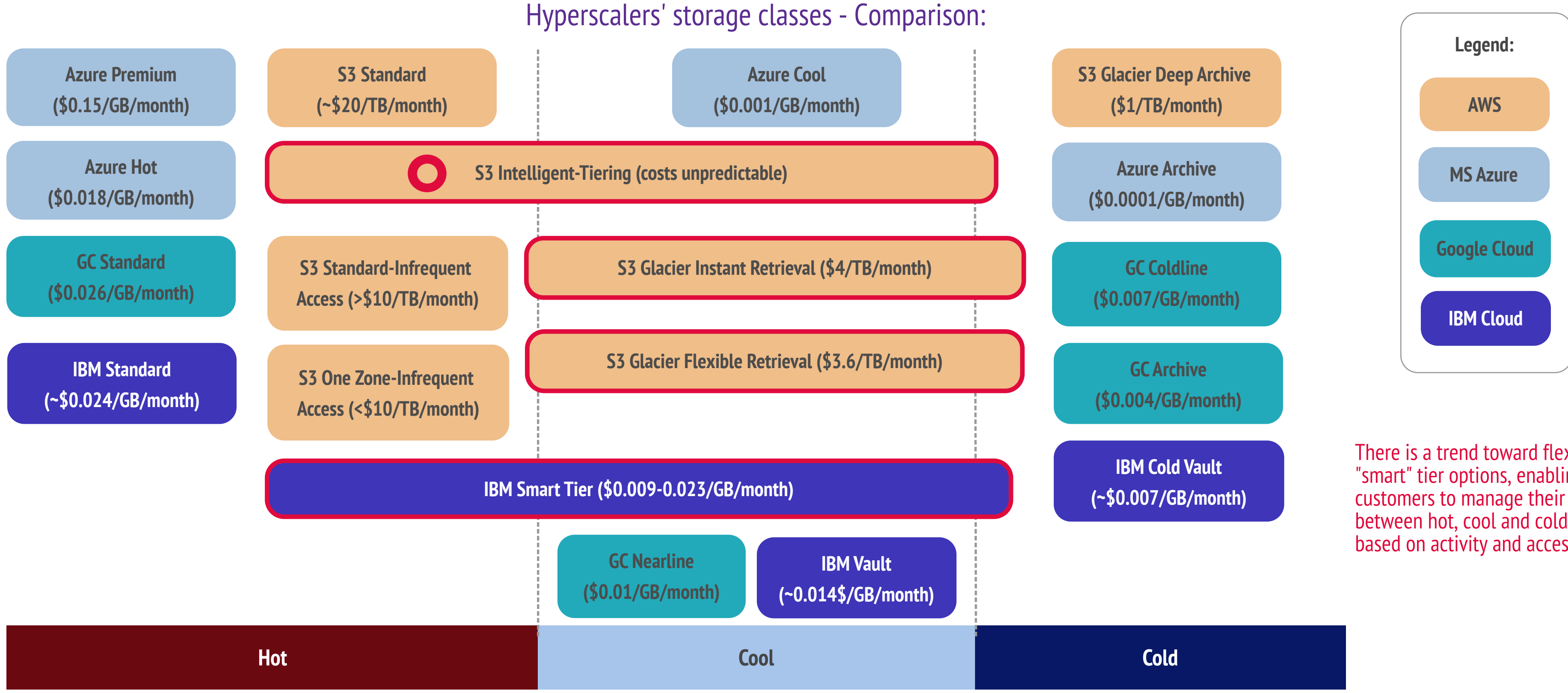


Sources: IABM, techtarget.com, tiger-technology.com, AWS

# Content Storage Tech Trends



## Cloud tier types



There is a trend toward flexible, "smart" tier options, enabling customers to manage their data between hot, cool and cold tiers based on activity and access.

Sources: IABM, techtarget.com, tiger-technology.com, AWS, IBM, Google, Microsoft



# Content Storage Tech Trends



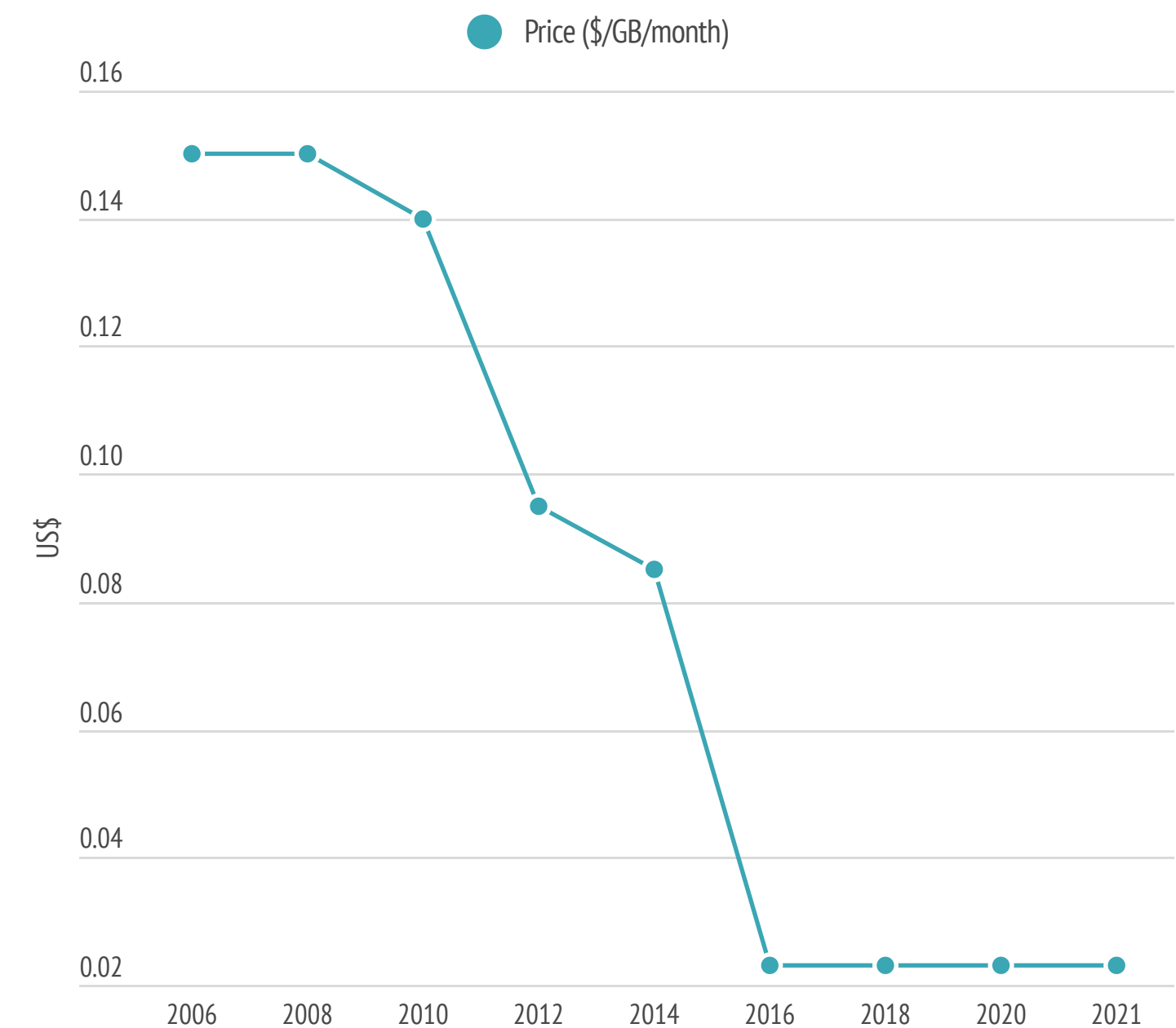
## Cloud pricing trends

### Public cloud service providers

**Adding "smart", flexible storage options:** Big hyperscalers (e.g., AWS, Google Cloud) are increasingly offering flexible, cross-tier storage options to enable customers to keep more of their data quickly accessible with lower egress and transport costs - the most expensive and unpredictable cost units for customers using public cloud storage. However, it is difficult to project real cost savings from these cross-tier pricing plans, because data access patterns may change more often than expected and the objects may be moved (automatically) between different tiers continuously.

**Pricing the option to use new services:** Big public cloud vendors continue "legitimize" their relatively high storage costs by adding in new services, which are reflected in the final price - whether these services were used or not. As a result, customers may end up paying for service options that are not relevant to their business (e.g., worldwide distribution of data with caching in China). The increasing complexity of these large scale cloud solutions is then being passed on to storage prices.

### Average AWS S3 Standard Tier storage cost



Sources: IABM, techtarget.com, tiger-technology.com, AWS, hawramani.com, Object Matrix



# Content Storage Tech Trends

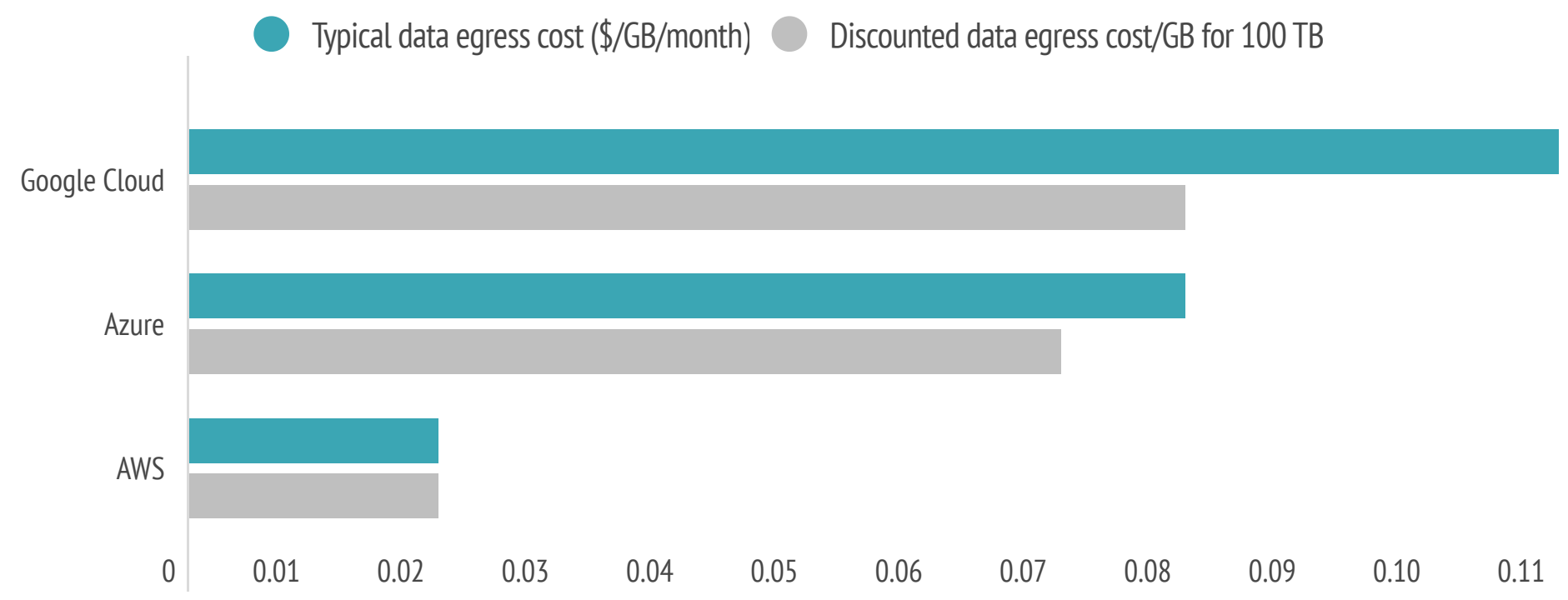
## Cloud pricing trends



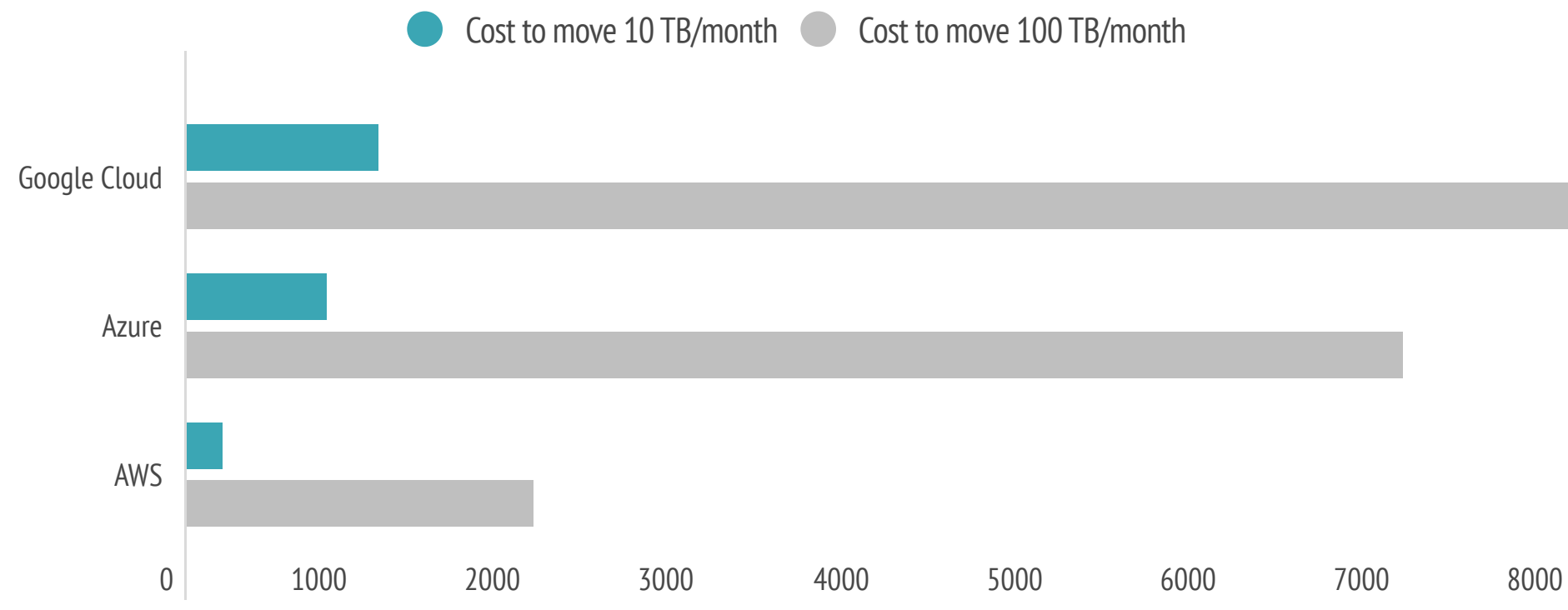
Amazon S3 reduced storage prices up to 30% in three S3 hot storage classes (S3 Standard-Infrequent Access, S3 One-Zone Infrequent Access, S3 Intelligent-Tiering Infrequent Access Tiers) and its S3 Glacier Flexible Retrieval class by 10% valid in selected regions in the US, APAC and Latin America. By pricing storage services significantly below the level of its major competitors, AWS attracts bigger volumes of data stored in its overall ecosystem.

Google announced significant cloud storage price increases across a number of core services effective in October 2022. For example, the price of Nearline storage will increase by 50%. At the same time, Google advised their customers to "adapt their current usage to better align their applications to these new business models and help mitigate some of the price changes".

### Hyperscalers' egress costs



### Hyperscalers' transport costs



Sources: IABM, techtarget.com, tiger-technology.com, AWS, Google, Microsoft, techcrunch.com, factioninc.com

# Content Storage Tech Trends



## Private cloud

### Private cloud service providers

**Eradicating price tiers and egress costs:** Private cloud providers like Wasabi are increasingly building their competitive advantage around simplicity, transparency and removal of egress fees - the opposite of large public cloud vendors' complex, unpredictable pricing models. Such one-size-fits-all storage solutions aim at reducing both on-premise and cloud storage costs by breaking down customers' several storage silos, which often slow down operations - and cause extra, unpredictable costs.

**Competing with security and compliance:** While private clouds cannot compete with public clouds' economies of scale, enabling hyperscalers to squeeze their infrastructure costs in the long-term, private clouds are competing with their managed security, compliance and monitoring services - these are increasingly business-critical functions for media organizations. Also, private clouds play an important role in media companies' short- and medium-term hybrid strategies given their large amount of legacy infrastructure causing diverse cloud needs.

### (Current) Private Cloud Benefits



**High level of utilization:** A private cloud is more likely to reach the required scale, making it cheaper compared to public clouds.



**Securing selected workflows:** Private clouds can be used for protecting workflows and data that need higher security infrastructure.



**Increasing flexibility of hybrid cloud models:** The use of private clouds alongside public clouds elevates a hybrid cloud's flexibility and adaptability to business-led needs.

Sources: IABM, techtarget.com, itpro.co.uk, spglobal.com

# Content Storage Tech Trends

## AI/ML & analytics



**Improved analytics:** As media companies move to the cloud, AI/ML will have an increasingly important role in asset management and identification due to the explosive growth of content to be stored - and to be discovered and retrieved quickly. As production levels in higher resolution formats increase, more storage space will be needed, highlighting the need for automated identification and removal of duplicated content.



**Intelligent automation & cost optimization:** AI-powered cloud computing can automate complex and repetitive tasks as well as monitor and optimize cloud costs. For example, AI/ML can be used to identify spending spikes and their causes (e.g., storage billing).



**Automation of cloud security:** As media companies continue to decentralize their resources, security risks increase when employees log into their systems remotely and when more production equipment is connected and communicating through the cloud. AI/ML is expected to be instrumental in improving data security when data is moved, used and stored in the cloud.

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*As resolutions get bigger you become more sensitive to wasting bits on storing the same content twice. So people will want [AI/ML] tools that help them know what is duplicated so they can go on storing the highest resolution [version of each item of content].*

*Simon Eldridge, Co-Founder & CPO, SDVI*

Sources: IABM, techtarget.com, itpro.co.uk, IBC365



# Content Storage Tech Trends

## High-performance storage technologies - NVMe

The need for faster analytics and AI/ML/DL tools has driven media companies to invest in solutions that enable better throughput (input/output-operations per second, IOPS), translating into faster time to market, revenues and actionable insights. In practice, investing in higher data storage performance technologies means consolidating storage and databases; fewer database servers reduce infrastructure costs.

As a result, the adoption of Non-Volatile Memory Express (NVMe) is growing steadily in many data storage systems. NVMe consists of a protocol for high-speed storage media and it is expected to become the new standard storage interface for future data center and corporate storage systems.

### High performance storage technologies - Comparison

	IOPS	Throughput	Latency	Queues	Commands per queue
SATA	60,000 to 100,000	6 Gbps	< 1 millisecond (ms) to > 100 ms	1	32
SAS	200,000 to 400,000	12 Gbps	< 100 microseconds to > 100 ms	1	256
NVMe	200,000 to 10,000,000	16 Gbps (Gen3x16)/ 32 Gbps (Gen4x16)	< 10 microseconds to 225 microseconds	65,535	64,000

Sources: IABM, techtarget.com, Forbes

# Conclusions

## Horizon for Connect and Store



COVID has had a long-lasting impact on the media and entertainment industry, causing the global shortage of semiconductors and other hardware components, leading to bottlenecks in production and sales. The pandemic has also accelerated the move to remote production, changing the architecture of the production model from centralized to decentralized. This is driving investment in IP connectivity and cloud, enabling collaboration, flexibility, and scalability.



The pandemic has also accelerated the move to the direct-to-consumer business model, causing a decline in satellite revenues. The move to direct-to-consumer is driving the demand for interactivity and immersive experiences, requiring higher bandwidth, gradually boosting demand for ST2110 and new codecs like HEVC. The growth of streaming audiences is increasing latency, thus shifting the investment focus of media companies, particularly operating in live sports production, to low-latency technologies, such as edge computing via cloud and 5G.