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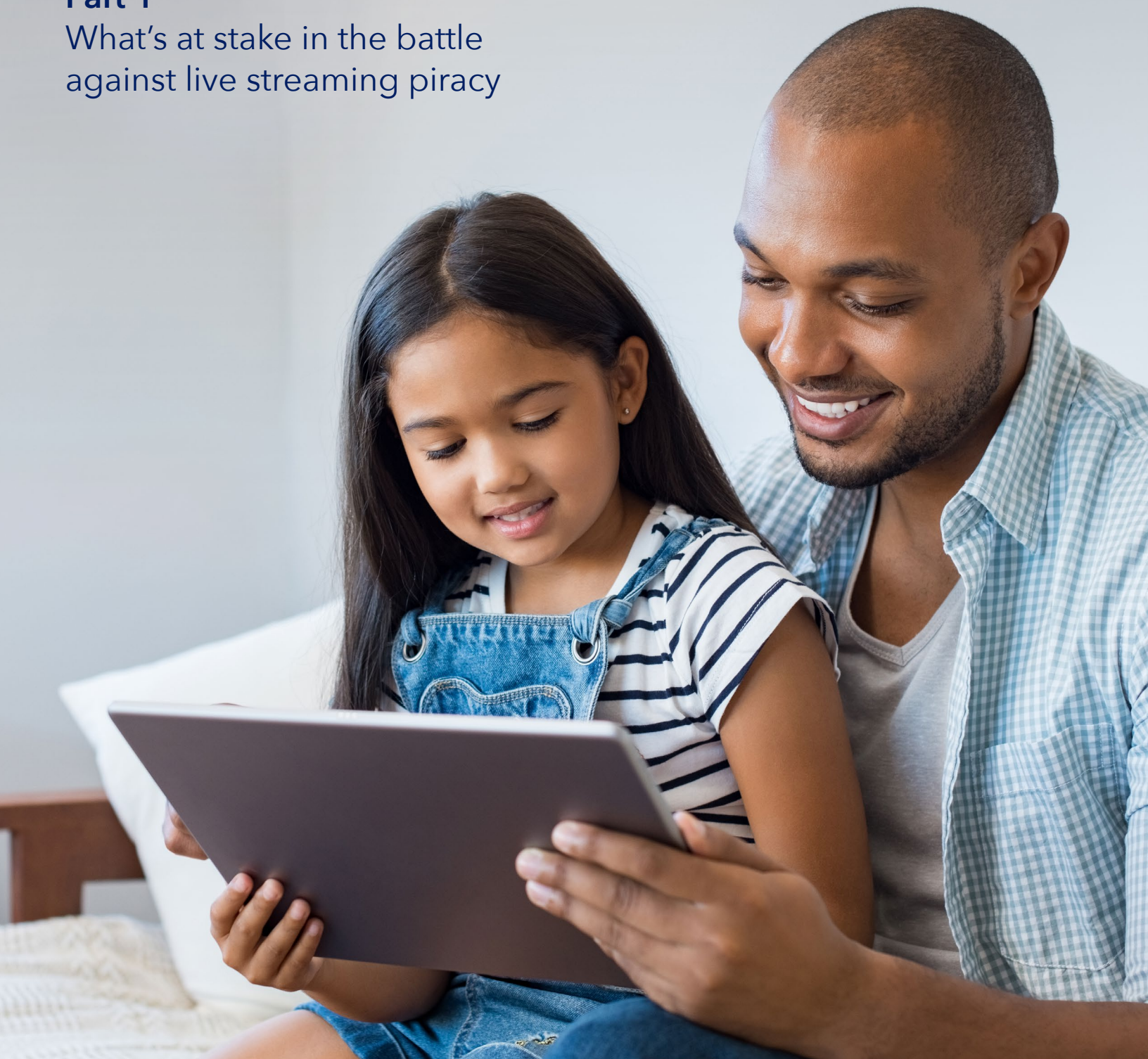
White Paper

ExpressPlay

New challenges and solutions to protecting live-streamed video

Part 1

What's at stake in the battle against live streaming piracy



Contents

Executive summary

Streaming of sports and other linear content has moved at lightning speed from the fringes of the OTT services marketplace to the mainstream as ever more consumers turn to online outlets for access to high-value content they once could only get from legacy TV providers.

Yet understanding how to adequately protect this content is not a simple thing. One must take into account all the types of content involved, how it is formatted, the importance of preserving a low-latency viewing experience with live streams and the scale and characteristics of the threat posed by online piracy.

Mounting losses to theft of high-value linear content, tempered momentarily by the coronavirus-induced sports lull, have triggered demand for tools and procedures that go well beyond the capabilities of today's security platforms optimized for on-demand viewing. But it's hard for content producers and their distributors to justify investments in new solutions without knowing if they will have a meaningful impact.

While a particular solution might be good at addressing a specific challenge raised by live streaming, such as the need to protect content with proactive forensic watermarking, the net benefits gleaned from choosing such a solution will be less than satisfactory unless all bases are covered. Complicating matters, the inventiveness of professional pirates combined with widespread consumer reliance on illegitimate providers creates a global mélange of constantly shifting tactics aimed at defeating advances in content protection.

The purpose of this two-part series is to first provide a complete picture of current challenges and outline the scope required to protect live-streamed sports and other linear content. Second, our goal is to describe how modern security mechanisms can be used to provide a comprehensive, tightly integrated protection solution.

In spelling out all the issues that must be addressed to create an effective response to illicit distribution of live-streamed content, this paper (Part 1) looks at the surge in live content consumption, losses attributable to theft and the methods pirates have devised to build audiences and thwart legitimate providers' defenses. In the next paper (Part 2), the discussion turns to the mechanisms that must be assembled to meet these challenges.

Audience and revenue of live streaming

Globally, the volume of live streaming grew 32% between Q4 2018 and Q4 2019, according to a report from Conviva, a leading supplier of video analytics technology.[1]

While on-demand viewing still generates the most traffic by a margin of two to one, live streaming is destined to surpass non-live traffic by 2024 according to Rethink Research.[2]

The shift reflects the fact that internet streaming has become the battleground for building audiences for live TV programming, which began in earnest just a few years ago when a handful of broadcast and cable networks began extending distribution rights for streaming linear broadcast channels to so-called "skinny bundlers." The trend has burgeoned into efforts by growing numbers of content owners worldwide to maximize audience reach through a potpourri of OTT services carrying live streams.

In this mix one finds:

- Free ad-supported and combination subscription/ad-supported packages from virtual multichannel video programming distributors (vMVPDs)
- A new crop of branded online outlets from legacy MVPDs
- Direct-to-consumer (D2C) services from the content owners themselves, including sports leagues that have mounted their own services in addition to licensing distribution to vMVPDs.

The end result is a large amount of content being streamed, putting a lot of money at risk, with the exposure of live content to online theft.

Digital TV Research projects subscription revenue generated globally by vMVPDs and D2C services that offer live as well as time-shifted content will increase six-fold by 2023, rising to a cumulative $23.68 billion from $4.14 billion in 2017.[3] But the biggest driver to revenue growth for these services will be advertising expenditures, which will generate $56 billion across all OTT services, including pure-ad play AVOD services, by 2024, according to another Digital TV Research Report.[4] These subscription and ad revenue sums represent 50% of the $160-billion revenue total forecast for all OTT services, which also includes about $80 billion in subscription revenues from SVOD services that don't offer live content.

These numbers offer a window on what's at stake in trying to limit piracy with live-streamed content. If, as predicted by Rethink, live streaming comprises 52.5% of the OTT streaming volume by 2024, it's reasonable to assume that revenue attributable to that content would equate to at least $40 billion, which is half of the projected $80 billion or so in ad and subscription revenues generated by services that offer live content. By comparison, the total ad/subscription revenue projected for legacy TV services globally in the 2024 time frame comes to about $435 billion.[5] (See Figure 1 for a summation of these calculations.)

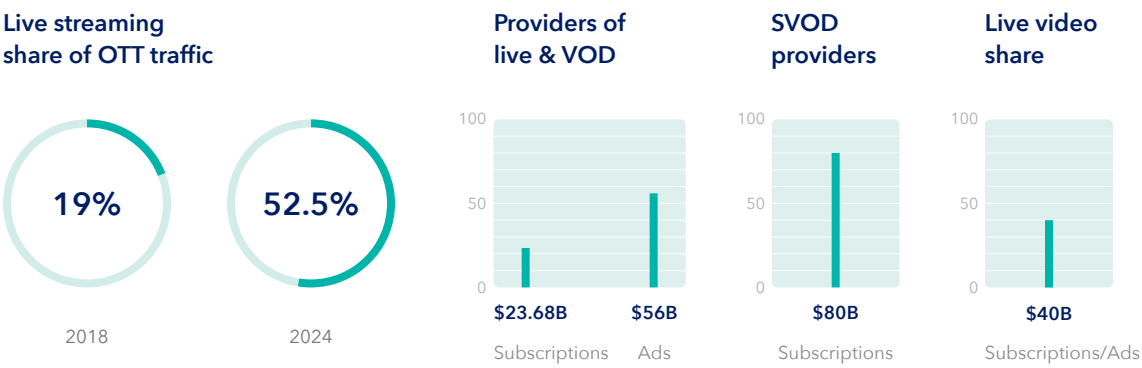
These projections predate the pandemic, which is sure to force revisions. But, as noted by Goldman Sachs,[6] the trends in play portend an acceleration on the digital side as ad dollars shift from traditional TV advertising at a faster pace in the aftermath of the pandemic.

The percentage of video viewing time going to OTT content is surging in tandem with the revenue numbers. Globally, viewers are spending an average of 6.8 hours per week consuming OTT video, with the U.S. topping the national averages at 8.55 hours, according to a report from CDN operator Limelight Networks.[7] In the U.S., Nielsen reports consumers with OTT connections are now spending nearly one fifth of their TV viewing time streaming content.[8]

Live streamed content has an even bigger pull on viewers than content streamed on demand. At 24.41 minutes per average view, the time spent viewing live streamed content is 27% higher than average time spent viewing an on-demand stream, according to the previously cited Conviva report.

Fig 1. The global perspective on OTT video trends

Projected OTT Revenues ca. 2024



The role of live sports

Live sports, which shut down with the advent of the coronavirus pandemic, by all accounts have been the biggest force behind live-stream viewing and are sure to resume that role.

Sports channels are now a routine component of virtual MVPD services like fubo TV, YouTube Live TV, Hulu Live TV and others while ever more special sports league packages have become mainstays of online viewing across the globe.

At the same time, demand for online access to live sports has brought major internet tech companies into competition for live streaming rights, including Amazon with its multi-year Thursday Night NFL and English Premier League (EPL) deals; Facebook with rights to Major League Baseball, Major League Soccer and a variety of college and international sports events, and Verizon with an NFL deal that has made games available on its AOL and Yahoo sites.

The surge in consumer demand for online access to sports events is evident everywhere. NBC Sports' experience with viewership during its 2016 Summer Olympics coverage offered one vivid example. The network reported a drop in traditional TV viewing compared to the 2012 summer games, but the amount of time viewers spent watching streamed coverage nearly doubled the streaming time spent with the 2012 London Summer Olympics and 2014 Sochi Winter Olympics combined.[9]

A more recent, equally dramatic example occurred during the Q4 2019 regular season NFL games. When those games were available for viewing online, Conviva saw an average per-game increase of 4% in total global video traffic with some games pushing the global spikes to 29%. In 2018, Conviva reported the FIFA World Cup had a similar impact on global traffic during the quarter finals. The peak level of concurrent sessions in the final game topped 9 million, which at the time was a record surpassing the previous high set by that year's Super Bowl.[10]

Peak record curves kept ascending right up to the Coronavirus outbreak. Fox, producer of the 2020 Super Bowl, said its average per-minute online viewer count at 3.4 million far outstripped previous Super Bowl averages.[11] Other events breaking streaming records in 2019 included the Rugby and Cricket World Cups, basketball's March Madness, the U.S. college football championship and many more.

The U.K. is another sports streaming hotbed. Sky Now TV, first launched in the U.K. and now available in many other countries as an OTT subscription service, has a heavy live sports schedule, and the company is also offering one-day pass options for streaming EPL matches. Not to be outdone, Amazon's Prime service has been featuring an a la carte offering allowing users to pay extra for any of 40 live streamed TV channels, including Eurosport.

Competing with Sky in the U.K., BT has been making coverage of Champions League and Europa League finals available on YouTube for several years. According to online video publisher Ooyala, more than 45% of sports viewing in the U.K. and Ireland occurs on smartphones and tablets.[12]

In Japan, Perform, a digital sports group with U.S. roots, has a ten-year contract to stream J-League soccer games, which can be purchased on a monthly as well as longer term basis through the DAZN online service. In India, licensing of sports rights by the dominant leagues, International Cricket Council and India Premier League, has been a key driver to the success of satellite provider Star India's online venture, Hotstar, which saw viewership on second year streaming of the two leagues surge to 87 million and 100 million, respectively, the latter representing a 144% jump over first year performance.[13]

Layered onto all this regionally focused activity are services where distributors have acquired rights to deliver sports and other content to consumers residing outside the countries of origin. Often these distributors operate independently of the in-country distributors, ensuring that rights holders can maximize their returns through subscriptions and advertising that would otherwise be lost to them.

Adding to the acceleration in live sports traffic, esports events (a form of sport competition using video games) have reached digital audience levels on par with traditional sports. In 2019, per-event viewership averaged 480 million, representing an 18% increase over the previous year, according to Futuresource Consulting.[14] Total time spent by all viewers streaming esports worldwide came to 5 billion hours, which led Netflix to identify esports as a bigger source of competition for viewership than any of its SVOD competitors.

The UHD/HDR factor

4K UHD-formatted content, often with high dynamic range/wide color gamut (HDR/WCG) enhancements, represents another trend impacting content protection requirements with live streaming. This is part of the broader migration to next-gen TV formats across the premium video services marketplace.

First and foremost, the acceleration in that migration is a function of the transition to a new generation of smart TV sets, which is now a fait accompli worldwide. According to projections from IHS Markit, Internet-connected smart TV penetration was on pace to top 50% in the U.S., Japan, U.K., France and Germany by 2019 with China close behind at 46%.[15]

Most of these are 4K UHD sets. According to Futuresource, global shipments of 4K sets will account for 52% of TV shipments in 2020, at which point the vast majority of television households in North America, Western Europe, Japan, South Korea and many other parts of the world will be watching TV on the big displays.[16]

Paralleling the penetration of 4K TV sets, expansion of the market base for 4K/HDR content has been fostered by an outpouring of 4K-compatible streaming media players (SMPs) from suppliers like Roku, Amazon and Google. As of 2018, more than half of the SMPs shipped in North America and Europe were equipped to support UHD, according to S&P Global Market Intelligence.[17] This was also expected to be the case with shipment tallies for Asia in 2019. While the volume of 4K UHD content available from MVPDs has been accelerating rapidly, the biggest forces behind 4K and 4K HDR content availability have been global OTT providers. Most of the leading OTT services are offering portions of their content in 4K UHD mode, much of it with HDR enhancements. Virtually all original content produced by Netflix and Amazon is offered in UHD, much of it enhanced with HDR.

At the same time, a growing volume of 4K content on linear TV channels has become part of OTT service bundles. The number of TV network channels carrying 4K content jumped from 70 worldwide in 2017 to over 250 in 2019, according to the latest figures from the Ultra HD Forum.[18] Adding to the momentum, an increasing share of live sports content was being streamed in 4K, ever more frequently with HDR enhancement, prior to the onset of the coronavirus. This trend is sure to resume.

While there had been some experimentation with live sports streaming in 4K prior to 2019, the pace picked up with recognition that broadband capacity in many localities was sufficient to accommodate the higher bitrates with 4K. The move to 4K was also motivated by progress toward consensus on HDR display modalities, which added to the benefits in viewing experience to be realized with 4K streaming to connected TV sets.

In fall 2019 Fox Sports began streaming some NFL games in 4K/HDR, culminating in the first 4K/HDR streaming of the Super Bowl in early 2020. In late 2019, BT Sport, which had been streaming soccer games in 4K for some time, laid claim to being the first European outlet to offer HDR-formatted 4K coverage of events year round, which were slated to include EPL and Union of European Football Association (UEFA) games before 2020 schedules were sidetracked. These BT Sport Premier games, including ones played in December 2019, were also scheduled for streaming as part of Amazon's new live sports agenda.

Also on tap but scuttled for the time being by the virus were 4K/HDR broadcasts of the 2020 Euro Soccer Championship and the Tokyo Summer Olympics. And in 2019 fuboTV began beta testing what it billed as the most robust platform for streaming live sports with offerings from the NFL, NCAA, MLB, women's soccer, EPL, and NASCAR.

Consumer sensitivities to latency with live streaming

Anything that introduces latency with live streaming, including execution of DRM and watermarking processes, is problematic and can severely impact viewership and ad impression metrics.

Online users want to view what's happening at the same time the action is displayed on TV screens, especially when engaging in group viewing through social media or when the viewer is on a second screen in proximity to a TV set showing the same event.

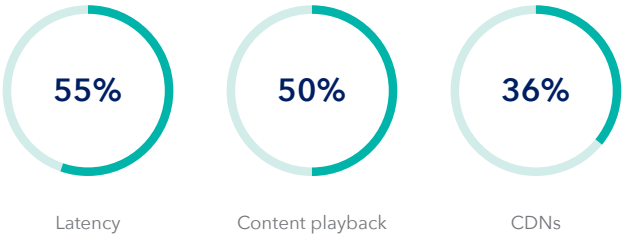
Latency-reducing transmission techniques have made it possible to stream sports and other live content at broadcast-caliber latencies, which is to say, with as little as six seconds in lag time between on-field action and on-screen rendering. And many service providers say they want to do even better than that (see Figure 2).

This prioritization of latency over other concerns reflects how little tolerance viewers have for longer delays, especially with sports content. Many studies bear this out.

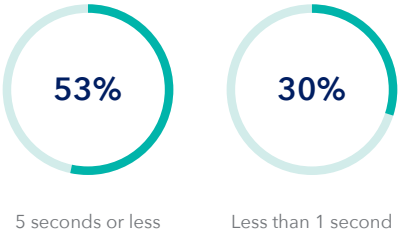
For example, previously cited research conducted by Limelight Networks found that 57.7% of surveyed consumers worldwide would be more likely to watch live sports online if they could be sure streams wouldn't exceed broadcast latencies.[21] A study conducted by Sapio Research for Verizon Media found that 19% of consumers regularly accessing online sports coverage cancel services that don't stream at broadcast latencies.[22]

Fig 2.

Top concerns most commonly cited by video professionals[19]



Latency preferences for live streaming[20]



The impact of piracy on sports and other live streaming services

Total losses to piracy of streamed content worldwide are skyrocketing, impacting live and on-demand services alike.

Digital TV Research projects that by 2022 global losses to online video piracy will reach $51.6 billion, nearly double the amount lost in 2016.[23] That's equivalent to 61.2% of the $83.4 billion the researcher says will be generated through legal access to streaming services in 2022.

These findings track closely with projections from Parks Associates, which estimates that $67 billion will be lost to streamed content theft in 2023, with about 55 billion of that total resulting from access to piracy sites, apps and devices and the remainder coming from individual credential sharing and restreaming.[24] In the U.S. 20% of broadband households report they use a piracy device, app or website, Parks says.

Judging from other reports, theft of live-streamed content is a heavy contributor to those loss totals. Internet technology supplier Sandvine reports that 6.5% of North American households access illegal live TV services every month, which equated to $4 billion in lost revenue for legitimate providers in 2017.[25] In a 10-country survey of over 6,000 sports fans, Ampere Analysis recently found that just over half are watching content from pirate services at least once a month.

In the U.K., a BT-commissioned study of young adults in the 18-24 bracket found that 54% of those surveyed take advantage of piracy to watch sports events.[26] The scale of the impact of piracy on live sports programming is also reflected in a report on illicit streaming of soccer games in Spain, which found the profit loss attributable to piracy came to about 270 million euros in 2016.[27]

How attack modes are expanding in the piracy ecosystem

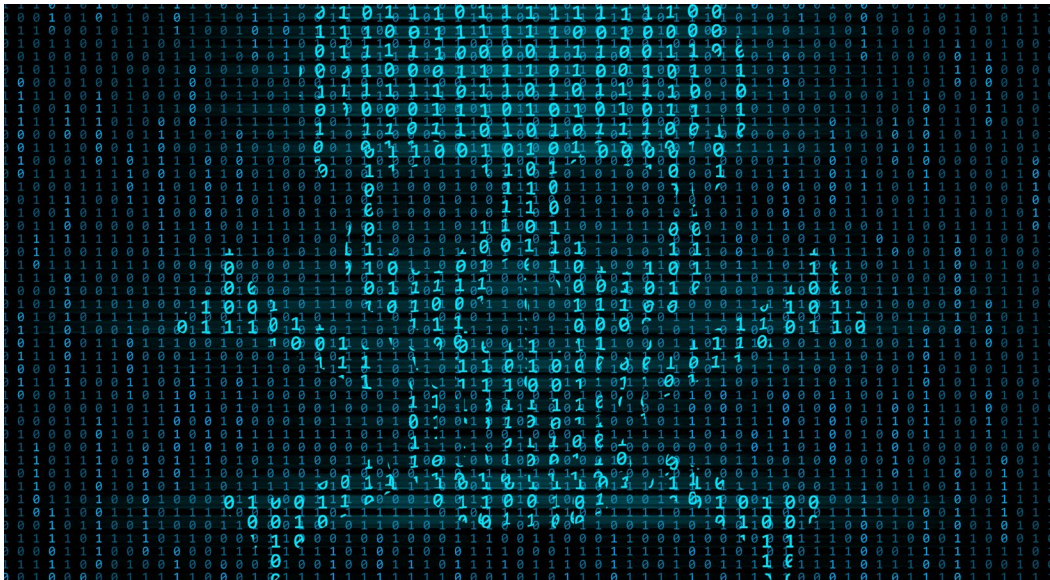
As shown by the scale of the loss estimates, piracy is big business and leverages the same advances in streaming, asset management, advertising support and other components of legitimate OTT service operations. They have the technical skills to develop and adopt new ways to defeat defenses and respond to detection with new brands and sites as often as necessary.

Approaches to skirting DRM protection

The least technically sophisticated approach professional pirates adopt to get around the robust protection provided by the sophisticated DRM systems with high-value content is the one also commonly employed by amateur thieves who restream content to their friends. Taking advantage of high-quality 4K TV displays and video cameras, the bad actors simply record and retransmit programming directly from the screen.

More advanced methods employed by professional pirate operations include use of high bandwidth digital content protection (HDCP) strippers to pull in-the-clear video from HDMI links to TV displays. This content can be instantly fed to origin servers for distribution of live content, imposing a latency penalty but otherwise measuring up to the quality levels of the originally streamed content.

In older devices without so-called Trusted Execution Environment (TEE) or Secure Video Path (SVP) support, pirates can capture in-the-clear content from device memory as it awaits playback in the buffering process. There are also so-called side-channel attacks, where hackers can extract the encryption keys without trying to break the AES (Advanced Encryption Standard) algorithms by using logic analyzers to read electronic wave or power consumption patterns. However, in modern chipsets there are several techniques to prevent different forms of side-channel attacks.



Deceptive service facades

Whatever they do to obtain the content, the most successful approach pirates employ to draw users is to run deeply discounted online services with linear portfolios, often with hundreds of channels. By aggregating purloined content into multichannel streams with professional-quality EPGs, pirates are able to deliver a user experience comparable to legal pay TV services--and steal their advertising and subscription fee revenue in the process.

These illegal services frequently organize the content into multi-language presentations, giving them international reach from anywhere in the world. They can add features and use interactive communications between clients and servers to tabulate device usage data, gauge the popularity of content offerings and perform troubleshooting in conjunction with sophisticated customer support services. Moreover they often benefit from ad revenues generated by online ad networks that mistake them for legitimate operations.

Sometimes apps offering pirate services also offer access to legitimate services at much higher prices, leaving the impression that the illegal sites are just bona fide competitors. Indeed, pirates have co-opted the "IPTV" label to the point that when people using these sites talk about where they're getting their ESPN or other channels, they say they're subscribing to IPTV.

A study focused on Millennials aged 18-35 in North America conducted by marketing firm LaunchLeap found that out of the 53% who admitted to having used illegal providers to stream TV shows and movies during the previous month, nearly two thirds said that streaming seemed "less wrong" than downloading.[28] As noted by ad agency Anatomy Media, the situation is even worse among younger Millennials. Drawing on a 2016 Google survey of 2,700 18-24 year-olds in the U.S., the agency reported that one quarter of the 69% in that age group who access pirated content think such activity is legal, and all think it is culturally acceptable.[29]

The Kodi factor

This piracy ecosystem heavily relies on the open software platform formerly known as Xbox Media Center (XBMC) and now operating under the Kodi brand. As a completely legal initiative administered and regularly updated by the non-profit XBMC Foundation, Kodi can be installed on Linux, OS X, Windows, iOS and Android devices to deliver a compelling unified experience on TV sets much as Chromecast or Apple TV does but without the content restrictions imposed by such proprietary systems.

Kodi is used to facilitate access to illegally streamed content in two ways. Consumers can search for and buy Web-advertised "fully loaded" Kodi boxes, which are devices preloaded with Kodi software and plug-ins that can provide users access to thousands of TV channels from all over the world. Or, after downloading and installing the Kodi software on their devices, users can download apps or "add-ons" from illegal sites that allow them to stream whatever content is offered from the site.

Sandvine, in the previously cited report, found that Kodi boxes supporting pre-loaded pirate apps account for 95% of the illegal live content consumption it measured in North America. The DIY approach accounts for the lion's share of the remaining 5% in illegal live streaming, Sandvine said.

Another key component in the new piracy ecosystem consists of VPN suppliers who advertise their ability to provide users access to geo-blocked content by changing their IP addresses to make it appear the users are located outside the blocked regions. Kodi VPNs specialize in unblocking users' access to geo-restricted Kodi add-ons.

One such VPN as described by a popular reviewer offers "its brilliant turbo speed server network in over 90 countries" and is "renowned for its superb HD streaming, live TV watching and high-speed torrent downloads." While operating legally, these VPNs often list on their websites a broad range of what are clearly Kodi add-ons from pirate sources, some specializing in sports, others offering a wide variety of live and on-demand content, all at no or radically reduced subscription rates.

It's also possible to subscribe to what is known as M3U playlists, which direct Kodi-enabled or other devices such as PCs, STBs and smart TVs running certain types of players or apps to pirate IPTV sites offering access to thousands of live sports and other TV streams. These playlists can be found through search engines or through specialized social media accounts.

At the same time, without having to pay for such listings, users searching for live sports streaming services can easily find online listings that include pirate sites as well as legitimate sources with messaging pointing out which ones are available at big discounts. The aforementioned study of online sports piracy in Spain found 78% of access to pirated content occurs through use of search engines.

Searches turn up articles that abound with headlines such as "Which is the best website for watching free live sports stream online?" "Get closer to the action with these sports streaming services," "How to Install TV Portal Kodi," "How to watch Euro 2016 Online from anywhere in the World." Consumers can find instructions that lead them through the process of downloading Kodi software or point them to sources of devices pre-loaded with Kodi software and pirated content.

Professional pirates are also making use of YouTube Live and Facebook Live to post and generate purloined content from TV shows and even entire channels with reliance on ad networks' placement of pre-roll ads to generate revenue. But, as reflected in the Sandvine study, these efforts pale next to the Kodi-based activities.

Attacks aimed at defeating watermarking

Further complicating matters is the fact that pirates are constantly coming up with ways to defeat the effectiveness of watermarks, even when, as prescribed by the motion picture industry's MovieLabs consortium, they are undetectable. Recent approaches to attacking watermarking effectiveness include intermittent blurring; chopping off the top and bottom of the screen, and, increasingly, random combining of multiple streams of the same piece of content into a single stream in a process known as collusion.

Another technique, focused on OTT streams, involves obscuring the source identity through direct penetration of the distributor's client app. In such cases, the watermark remains intact but becomes associated with a phony ID.

Effective protection that answers the challenge

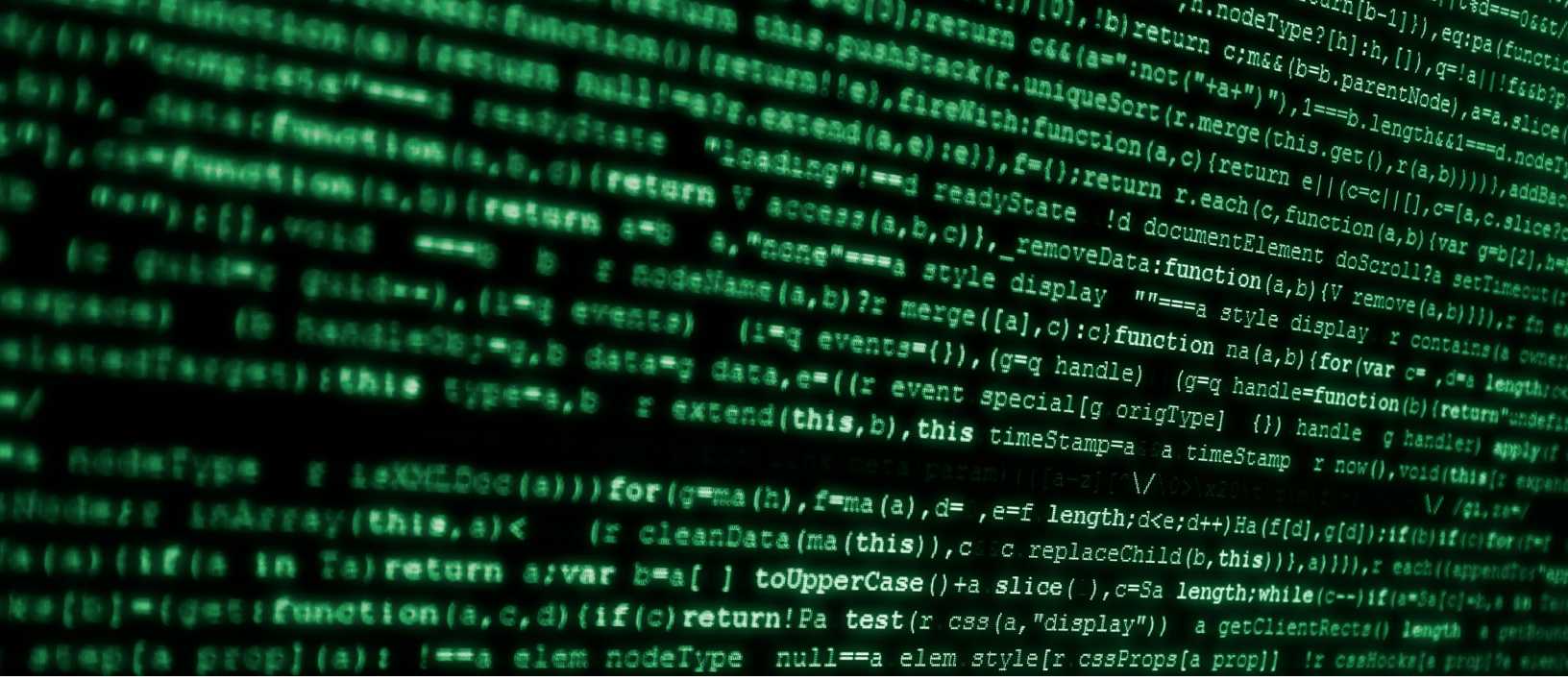
As daunting as the methods and pervasiveness of piracy might be, the good news is content producers and distributors are learning that investment in aggressive countermeasures pays off.

A growing body of evidence shows that when such initiatives are mounted against sports and other live-streamed content piracy, they can have a disproportionately devastating and immediate impact on illegal operatives compared to what it takes to thwart illicit viewing of time-shifted material.

In the latter case, discouraging individual users of pirate sources through messaging responses to or disruptions of their viewing experiences is a cumulative process requiring ongoing action one viewer at a time. In contrast, a more successful approach is to discourage such behavior on the part of a lot of people all at once. For live sports, for example, getting notices calling them out for engaging in illegal behavior or having their streams cut off as the game is getting underway is a powerful inducement to questioning the wisdom of going back for more.

If there's an upside to battling the live streaming piracy scourge, this would be it. Given that, as noted earlier, users are often either unaware that what they're watching has been stolen or don't know it's illegal to watch stolen content, it makes sense that letting them know otherwise in no uncertain terms would have a significant impact on illicit consumption.

The point was made in 2019 when the U.K.'s Sky reported it had benefited from massive streaming disruptions to pirated EPL games the year before.[30] After the league and distributors cooperated to disrupt over 200,000 illegal streams, Sky said viewership of 17 matches carried by its services more than doubled the combined audience totals for the previous two years.



Of course, the best results occur when both immediate disruption and legal action are working in tandem against live streaming piracy. Publicity about successful prosecution of pirates has an impact that goes beyond shutting down a given operation by creating a chilling effect on illicit consumption in general, especially when users know legitimate options are available to stream the sports and other things they want to watch.

While a single action like the U.K. court-ordered shut-down of peer-to-peer site The Pirate Bay in 2012 may not be enough to significantly impact user behavior, the outcome is different when multiple cases in a given region are clustered together. Looking at the aftermath in the case of The Pirate Bay, research conducted by Carnegie Mellon University's H. John III Hein School of Public Policy and Management found just a slight reduction in total piracy within the U.K. with no noticeable increase in the use of legal sites.[31]

But following court action against 19 sites in 2013, the researchers measured a 12% increase in use of legal sites. Furthermore, after court actions against 53 piracy sites in 2014, they recorded a 16% decrease in viewing of pirated video among U.K. users.

Such results have inspired widespread confidence that well-executed action against pirates will produce meaningful results. This has led to a surge in collaborative efforts, especially in Europe.

In the Netherlands, for example, law enforcement have engaged in a series of successful actions against piracy spearheaded by Vodafone, Ziggo and the Audiovisual Anti-Piracy Alliance. In Spain, arrests in several cities in 2019 shut down a piracy network serving thousands of users in 15 countries.

A study by Ampere Analysis looking at three-year trends in the U.S. and Europe offered a measure of the effectiveness of legal enforcement combined with increases in availability of legitimate sports streaming services.[32] Overall, use of pirate sports services dropped from 7% of consumers with internet access to 4% between Q1 2016 and Q1 2019, the researcher said.

Going forward, widespread adoption of comprehensive measures aimed at thwarting piracy against both live and time-shifted video could produce billions of dollars in recovered revenue. Looking at the previously cited projections for total annual losses to piracy in the $50-billion range in the 2022-2024 timeframe, it's reasonable to assume the industry could recover on the order of $10+ billion through protection mechanisms that are sufficiently effective to convert just one in four pirate customers to legal users.

Conclusion

The sophistication, alacrity and pervasiveness of pirate attacks on high-value live-streamed sports and other linear content have produced a scourge that must be dealt with.

With the volume of live video traffic on track to exceed that of time-shifted content in just a few years, an ever-increasing share of the tens of billions of dollars lost to piracy will be attributable to attacks on sports and other linear content.

Adding to the appeal, pirates have been responsive to consumer demand for low-latency delivery of sports and other live-streamed content, creating an environment where legitimate service providers must take care to avoid imposing streaming delays on their own services when they implement more rigorous protection mechanisms. Thus, distributors have the double whammy of needing to implement technology that streams their own content at the lowest possible latency while also ensuring that watermarking and other steps taken to maximize the impact of disruption against purloined content streams can get the job done fast enough to be effective against pirates' low-latency streaming techniques.

So what's to be done and how can operators best meet this challenge? In part two of our series we will focus on creating an effective security strategy and how it is achieved through a modern content protection solution.

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