Digital Broadcast Video Streaming

Technical Challenges, Solutions and Intellectual Property Protection

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Executive Summary

Broadcast network operators and communications service providers have to make digital video broadcasting meet a number of contradicting requirements in order to maintain its growth trajectory and monetize the associated traffic. The main contradiction lies in the simple fact that the underlying technology is based on a point-to-point technology trying to mimic one-to-many broadcast technology.

However, broadcasting via IP networks can offer significant advantages as well as the ability to provide additional services around the actual broadcast, allowing access to extended, new customer groups and new audiences.

This white paper outlines the technical challenges facing video over IP business models and the associated issue of intellectual property protection, discusses possible solutions, and offers a route to success in this dynamic and fast-changing market.

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Market Situation

The Internet has changed everything.

This broad statement has been seen many times in recent years and is truer than ever for the broadcasting market. There used to be three means of distributing broadcast content: satellite, cable and over-the-air broadcast. In all of these cases, “broadcast” truly meant linear broadcast, i.e. one source being distributed to multiple destinations.

This has changed with the advent of the Internet as a medium for broadcasting.

Linear has become on-demand, the screen sizes have multiplied in size but also in the number of different sizes used to display content, from small mobile phones with a minimal three inch 640x320 pixel to huge 4k and upcoming 8k UltraHD displays measuring in wall sizes, as well as different frame rates from 15 frames per second (fps) to 60 and 100 fps.

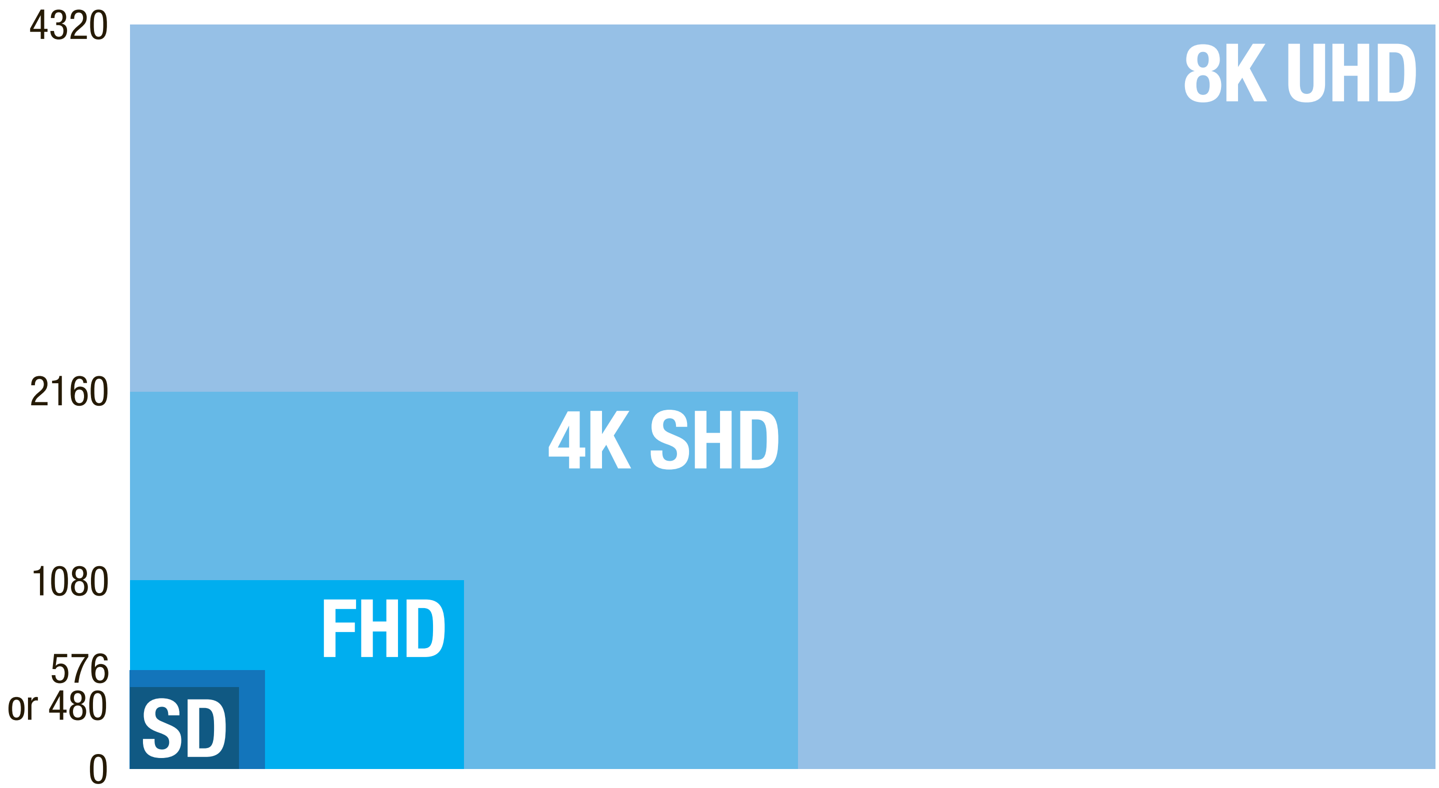


Figure 1: Comparison of image sizes

As a result, supporting video over the Internet creates not only a number of challenges for video providers (TV stations in the linear broadcast world), it also allows them to address new markets and new customers with new business models.

All these models, however, need to be able to cope with the limitations and options for Internet access and connected devices. Content providers must also see these business models as adding value while contributing to customer retention and meeting their return on investment goals.

Encoding	H.265 Bit Rate Savings Relative to:			
	H.264/MPEG-4 AVC H	H.263 CHC	MPEG-4 ASP	MPEG-2/ H.262 MP
HEVC MP	40.3%	67.9%	72.3%	80.1%
H.264/MPEG-4 AVC HP	-	46.8%	54.1%	67.0%
H-263 CHC	-	-	12.2%	37.4%
MPEG-4 ASP	-	-	-	27.8%

Table 1: Average Bit Rate Savings. Source: Comparison of Coding Efficiency of Video Coding Standards, Fraunhofer HHI

The challenges

As outlined above, there are a number of competing challenges to broadcast providers that need to be addressed by new technology.

Broadcasting in an IP world

Unlike traditional broadcast, where a broadcaster "owns" a certain frequency for use to broadcast to everyone within reach, IP networks are a shared medium connecting single end points. As a result, instead of a single broadcast, there is a direct connection between broadcaster and receiver, resulting in a high number of connections departing from the broadcaster to its individual recipients of content. This, in turn, results in a multitude of requirements and challenges that need resolving.

Device	Max. Rate Mbit/s	
Raw 1080p60	3000	100.0%
Blu Ray HD Movies	54	1.8%
H.264/AVC HD	5	0.2%
H.265 HD	3	0.1%

Table 2: Typical bandwidth requirements for various codecs

Total traffic generated

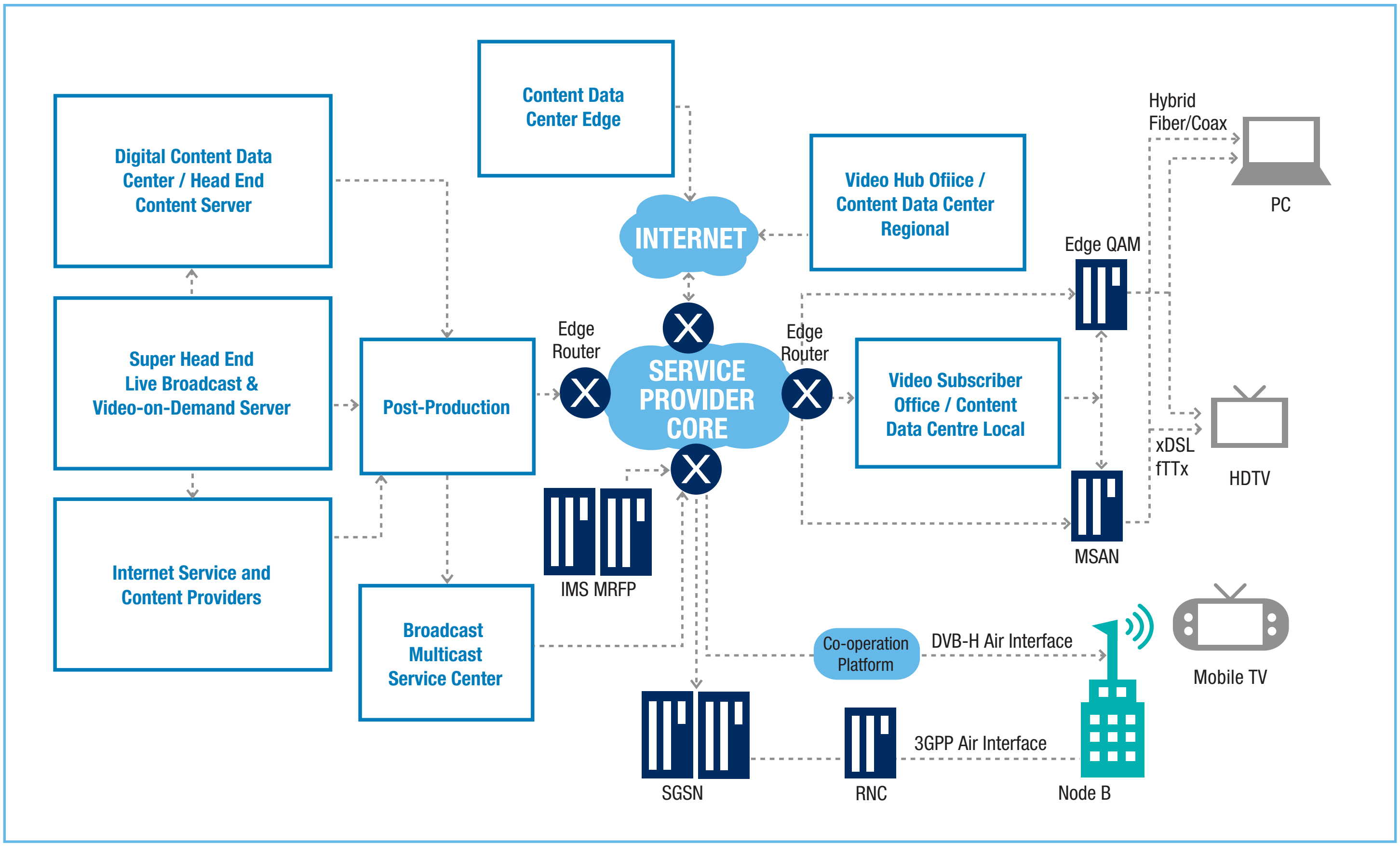
If you provide a source of IP traffic to the Internet, you have to pay for the traffic you generate. Generally, this will be done through a peering agreement between providers, which assumes there is more or less the same amount of traffic moving between networks. If you are providing video streams, this definitely is not the case – your downstream will be significantly higher than the upstream into your servers.

Additionally, you can expect to see massive requirements on bandwidth, also resulting in additional cost; a 10G line from Verizon or Deutsche Telekom has been reported to cost many thousands of dollars a month. This endeavor will be really expensive, not even accounting for the cost of the actual traffic created.

Cost can be controlled to a certain extent by ensuring that only streams in the resolution required by the viewer's device are streamed to that viewer, thus limiting the bandwidth required, as well as getting closer to the end customer using content distribution networks (CDN).

Routes, Streams and Latency

Now you are able to get your video streams out towards your customers, they need to get there reliably and safely. After all, there is nothing more distracting and frustrating than watching a suspense movie that starts to buffer or stops completely right the moment before the culprit is found!



One view of the digital broadcast video streaming network architecture, which highlights the complexity of broadcasting in a multi-screen, IP world.

The nature of the Internet includes massive flexibility in the way data packets reach their destination. This, in turn, means that there is no guarantee that all packets for the same stream take the same path (called route) and arrive in the sequence they were sent. This, in turn, means there is a potential time delay (latency) between packets arriving, and the order in which they are required to show the movie. To work around this, the popular method of buffering is used. Of course, this also means when watching live events, there is a certain delay between when something takes place in the real world, and the time the machine displaying the streamed content actually displays it.

In fact, a similar delay (for different reasons) is present in all ways in broadcast media. The shortest possible delay is in over-the-air analog broadcast, as the signal is simply sent and travels at the speed of light to the antenna, where it is in turn converted into the image displayed. The moment you change to digital video, there is a delay introduced due to the encoding of the analog signal into the digital signal. In case of cable TV, additional latency may be introduced by moving the signal from one frequency to a different frequency.

So, whatever you do, there will be latency. Whether it is worse than IPTV or not, depends on the actual circumstances. Routes are just one part of the equation, and can be controlled to a certain level by placing the content closer to the viewer, and by having the required resolution available in the right place in the network.

Available Bandwidth

It is not just distance and device screen size that determines the experience of viewing video. As the packet stream travels through an undefined number of networks, the minimal bandwidth somewhere on the way ultimately defines the maximum available bandwidth for the stream. So, sometimes it does not matter whether someone else in your network is downloading a large file or not – you may still not receive the movie in HD quality because, somewhere along the way, there is something else making the pipe very narrow.

Server Capacity

And, last but not least, a critical factor is the capacity of the servers playing out, selecting and sending the stream. Here, the tasks the server needs to perform, together with the network connectivity of the server play a massive role.

Assuming that the media file is already present on the server disk in the right resolution and format, may not be correct. Typically, a large number of both formats and related resolutions will be pre-encoded unless viewing a live stream, but some may not. Depending on the vendor's policy, that results in real-time transcoding, so decoding the movie into raw data, then re-encoding it in the right format and size. This is extremely burdensome on the server's processors, and may even limit the available bandwidth to other users of the same service. Here, the price/performance decision of the provider comes into play, as over-provisioning server capacity of course also has a cost impact.

Time Shifting and Other Features

Finally, there are features that users have become accustomed to when using video recording devices. All these need to be supported and enabled in streaming applications as well, meaning for example that you can skip forwards or backwards in the movie, and expect to more-or-less instantaneously be able to start watching from that point.

This, in turn, requires the server to understand the new position in the movie, move to the right frame and re-send it or send it even though the played movie before was at a different position.

Depending on the rights purchased for a movie, these functions or, specifically, skipping advertisements and other undesired parts may be disabled either generally, or per movie by the video provider.

Mobile and not-so-mobile Devices

Another major challenge in IP-based broadcasting is the fact that there are so many different devices, with different display capabilities and screen sizes. Each and every one of these requires its own stream, preferably with the correct resolution for both available bandwidth, screen size and device power.

Available Bandwidth

As already discussed, the goal must be to achieve the optimal combination of utilizing the total available bandwidth, cost for transmitting content over IP and the quality of the material displayed. Sometimes, the tradeoff may be to have slightly lower quality but a higher frame rate and so show more fluid movements, for example action movies, whereas sometimes, higher quality and lower frame rates may be preferred. Ultimately, the tradeoff will need to be made, sometimes by the user, sometimes by the vendor.

Device Screen Size

This is a major determining factor in the equation. There is no use in viewing HD material on a 320x240 3 inch display. But, sometimes, users will make this choice and create multiple issues not just along the way, but also for themselves. If the user device itself needs to do the decoding and resizing of the image, this will use considerable processing and, as a result, battery power.

There are multiple solutions to this dilemma, including session border controllers (SBCs) deployed in networks that can transcode the movie to fit the end user's device on-the-fly. However, every node in the path "before" this device will need to support the full HD stream.

Device Power

Mobile devices are, unlike fixed TVs, built to live from a tiny battery for a prolonged period of time. This battery not only needs to feed the display, transmission and reception units but also needs to do the resizing of the stream received, if this is not done somewhere earlier along the way. Ultimately, there needs to be a negotiation between the server sending the stream and the end user device to figure out the right combination of all parameters that meets all requirements as well as the user needs for an extended battery life time.

Having discussed some of the technical challenges facing video over IP business models, it is now appropriate to introduce the associated issue of intellectual property protection.

Intellectual Property Protection

As more and more bandwidth is becoming available to satisfy the ever-growing demand, this increases the possibility of threats of piracy and theft of material protected by intellectual property regulations. While on the other hand, protection measures should still make it easy for legitimate users to access and consume content.

A short history

In the traditional broadcast world, content was protected through various means. Content Scrambling System (CSS) was used to protect content on DVDs from illegitimate copying. This was broken fairly early in the process, leading to a mixture of protected and unprotected DVDs being sold. A newer standard for playing back any content has been introduced with the advent of HDMI.

HDMI not only defines a physical interface to connect any kind of media device together, it also defines a standard called High Definition Copy Protection (HDCP) that enforces encrypted communication from the source of content, be this satellite broadcast or a Blu-ray disc, or anything else, to the actual device showing and playing the protected content by creating a chain of trust from end to end. If, at any point between these steps, either a non-licensed or non-trusted unit is found, the content will not be forwarded and will not be played. This includes much-disputed flags that disable functions such as fast forward or replay that we have gotten used to, as well as safety measures to protect content.

The content and broadcast industry aims to carry most, if not all, of these protections over into the new IP-based world of media.

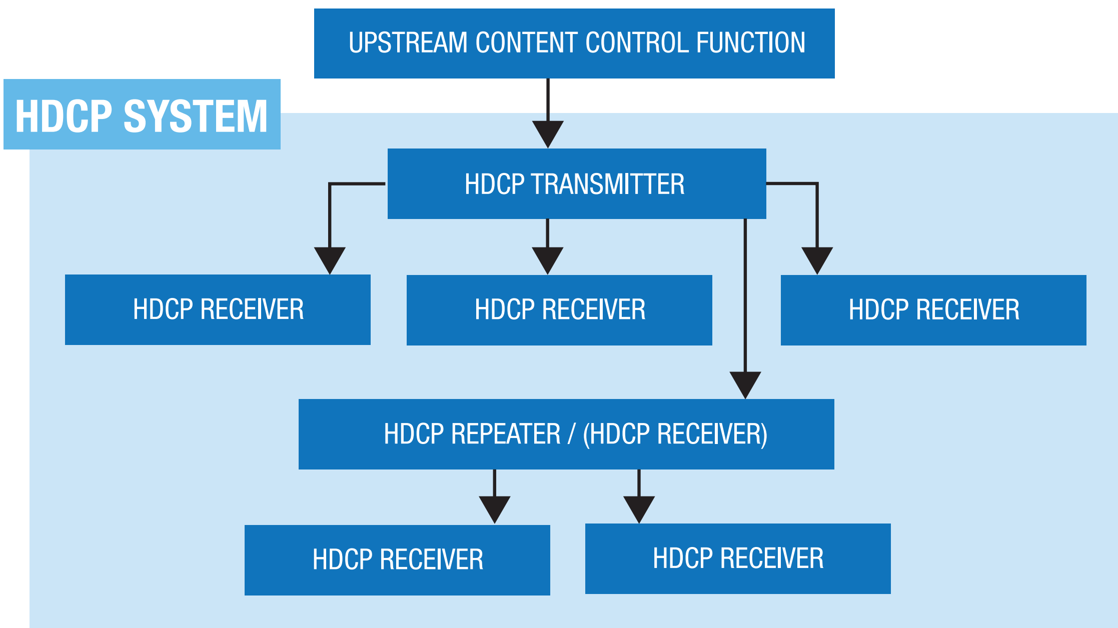


Figure 1-1: Sample connection Topology of an HDCP System

Threats

The largest threat if you are publishing copyrighted material is simple theft – especially in an all-digital environment, it has become easier than ever before to create exact copies of material that is sent to you in some way, be it on DVD, Blu-ray or via the Internet. Delivery via the Internet creates an additional threat vector, as it enables theft of the material anywhere along the route from the publisher to the recipient. So, both transport and display need to be protected to protect licensed IP and avoid penalty charges.

Solutions

There are multiple ways to protect intellectual property on the way.

Of course, you can follow the established route of HDMI with its chain of trust from disk to display, and build this out to cover the Internet connection as well. This is undefined as of today, and may actually be superseded by already available technology.

Encrypted Streams

The primary choice would be to encrypt the content being sent. This way, you can ensure not only that content is not tampered with, but also that only approved recipients can decrypt and view the protected content.

This can be achieved in real time, and with a specific key per viewer. The viewer's key can be determined either using the viewer's conditional access module (CAM) or a virtual CAM embedded into the app used to view the content that is bound to the user's account. This method is probably the safest, while it would also be the most demanding on both ends of the stream. It requires real time encryption on the playout server, and real time decryption on the viewing device, which is likely to be battery powered. The encryption on the server side can be performed using plug-in cards to massively boost capacity, while retaining the form factor and existing server infrastructure, thus improving density as well as the security of the solution. The downside of this solution is that every single stream has to be processed at the time it is sent out, which requires massive computing power – but this can be countered using dedicated plug-in cards.

Pre-encryption

Another option would be to pre-encrypt the streams into containers, and use a key exchange protocol, authenticating the user prior to transferring the key in a protected manner. This also requires a lot of computing power as all streams and resolutions need to be rendered and encrypted prior to being sent out, but allows usage of content delivery networks (CDNs) as well as flexible distribution. The key exchange requires minimal computing power, but the pre-encryption as part of the rendering process imposes high requirements on the computing infrastructure. However, once done, the protection is present in the container and can easily scale out. Plug-in cards such as Artesyn's SharpCaster™ PCIE-8205 broadcast video accelerator can multiply the speed of the rendering and encryption process by magnitudes, freeing valuable rack space for other revenue-generating tasks. Decryption still remains a task that needs to be executed on the display device, so it remains a requirement to make a prudent choice of a decryption algorithm that can be used in a battery-saving manner.

Watermarking

To distribute protected content via an unprotected media, the least stressful option for the viewing device is to use a watermark. This watermark is embedded into the media stream, unique to the viewer and not removable from the stream without destroying that content stream. The protection function in this method is the fact that if the content is copied, it has a reference to its source that cannot be removed. This creates the psychological pressure that the content source can be tracked, potentially creating a legal liability. Watermarking makes life easy for the end device – after authentication, the only task for the display device is to decode the content for display on the screen in the proper format.

The integration of the watermark into the stream sent imposes a minimal performance overhead on the delivering server, allowing a massive amount of streams to be handled by a server, especially when using plug-in acceleration cards to conduct the insertion, with the actual server processors just being tasked to do the tracking and control functions in a single box.

Next-generation Screens

Another interesting challenge coming our way and looking for a solution is UltraHD in its 4k and 8k iterations. These screens essentially mean the growth of a single stream by a factor four to eight due to the screen size alone, and another factor of two to four for the high frame rates associated with it, creating a total increased stream size factor of 10-25. The associated processing power required to handle encryption and encoding, decryption and decoding as well as watermarking is significant.

Acceleration devices inserted into servers enable in-place upgrades of the existing server capacity without requiring major changes and updates to the software running on the servers, beyond the support packages and function blocks that need to be installed on these plug-in cards. Depending on the architecture of the cards, they can be used to either maximize density or maximize transcoding capacity, which is required for the growing number of large screens.

Outlook

Over time, video over IP will dominate even more the growth of data in all networks. Content Delivery Networks, as well as content generators, will need to grow their capabilities to provide more and more streams in higher density closer to the end customer.

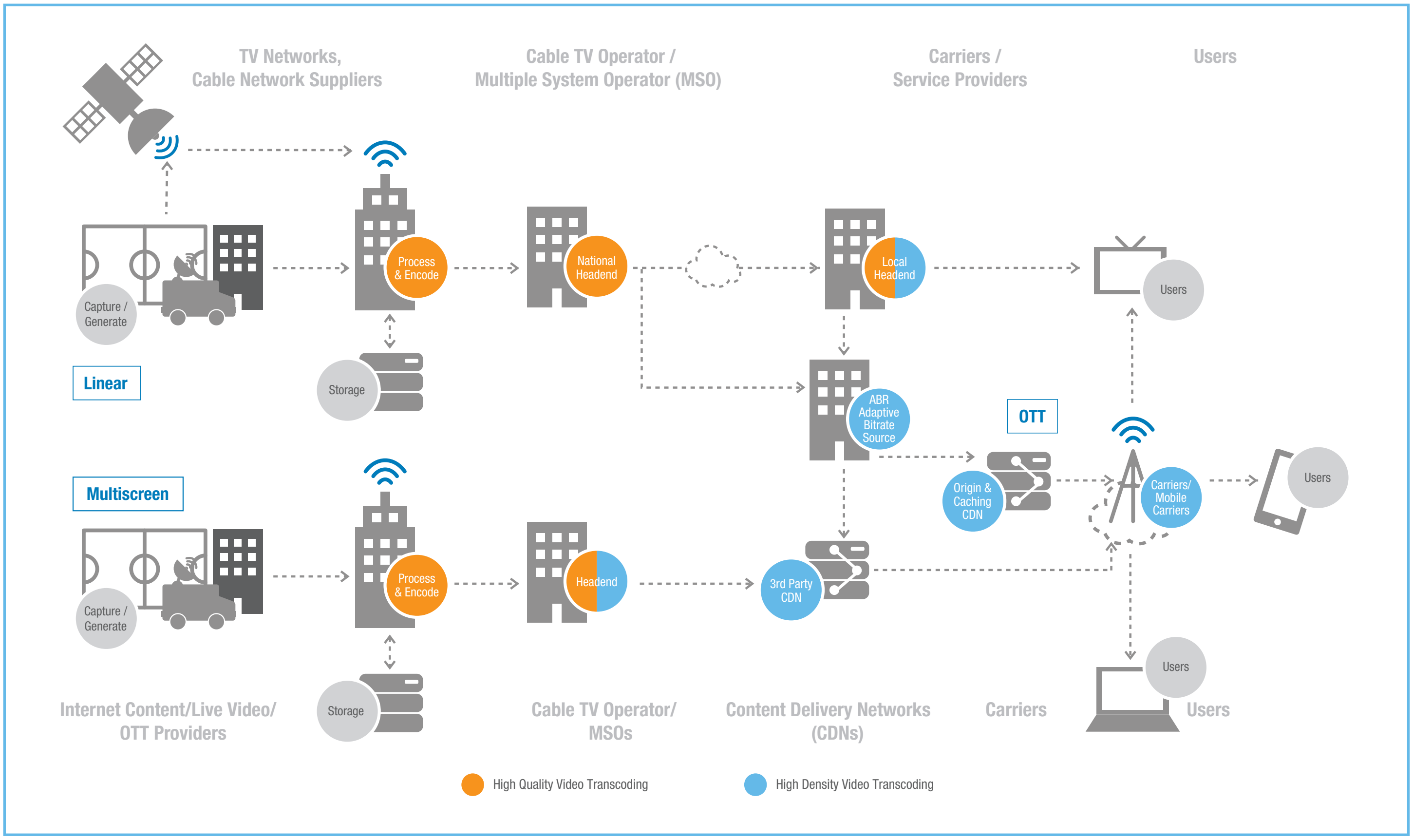
This is driving an intense transformation in the broadcast network infrastructure, resulting in a change to the way broadcast distribution equipment is built. Innovation is the key to accommodate the sharp rise of video traffic and its need to support multiple types of devices using less bandwidth.

Service providers can either keep adding servers and their associated capital and operating expense, or optimize their existing systems using off-the-shelf solutions for more scalability.

Artesyn Embedded Technologies' video acceleration products offer tailor-made solutions to grow server capacity without replacing entire racks of equipment and as a result support the trend to better quality video offered more locally in a manner that ideally suits the business model of all parties involved.

Artesyn Solutions for Broadcast Video Streaming

Artesyn's embedded acceleration cards, together with the extensive software packages provided to support not just drivers but also add-on packages such as media software development kits as well as the extensive support by major vendors in the broadcast market, offer customers a seamless upgrade without having to replace servers they have deployed today. The selection of cards allows not only the right tradeoff between density and quality, it also enables vendors of devices to add their own code and so create even more applications that fit the exact market space they are targeting, and allows them to develop other creative opportunities for new business models.



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Artesyn Embedded Technologies is a global leader in the design and manufacture of highly reliable embedded computing solutions for a wide range of industries including communications, military, aerospace and industrial automation.

Building on the acquired heritage of industry leaders such as Motorola Computer Group and Force Computers, Artesyn is a recognized leading provider of advanced network computing solutions ranging from application ready platforms, single board computers, enclosures, blades and modules to enabling software and professional services.

For more than 40 years, customers have trusted Artesyn to help them accelerate time-to-market, reduce risk and shift development efforts to the deployment of new, value-add features and services that build market share.

Artesyn has over 20,000 employees worldwide across nine engineering centers of excellence, five world-class manufacturing facilities, and global sales and support offices.

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