White Paper

Challenges of Distributing 4K Video

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Introduction

4K video delivers stunning beauty and resolution. But like most new technology, it comes with challenges to overcome as well.

Enormous bandwidth (10 Gbit/s) is required to deliver 4K video. This places unprecedented demands on infrastructure. To be successful in real world applications, 4K distribution systems must be designed and engineered to address the following five challenges:

- Mismatched resolutions
- New frame rate considerations
- Signal integrity issues
- New cable length restrictions
- Source/display compatibility

Manufacturers of 4K sources and displays must take a holistic approach to testing their products to ensure that they are up to the challenges of an integrated 4K system, liberating system designers and integrators from having to take on this daunting challenge themselves.

In this paper we'll explain how you can conquer the challenges of 4K video distribution. You'll learn about the unique attributes of this exciting new resolution and why DigitalMedia has established itself as the clear leader in 4K distribution.

4K technology overview

The term “4K” is used generally to refer to video signals with a horizontal resolution on the order of 4,000 pixels. Previous generations of video resolutions were described by the vertical resolution (e.g., 1080p refers to a signal with 1080 vertical lines). Had the naming convention for SD and HD been used, 4K video might instead be referred to as “2160p”.

The increase in resolution presented by 4K is tremendous, as characterized in this diagram:

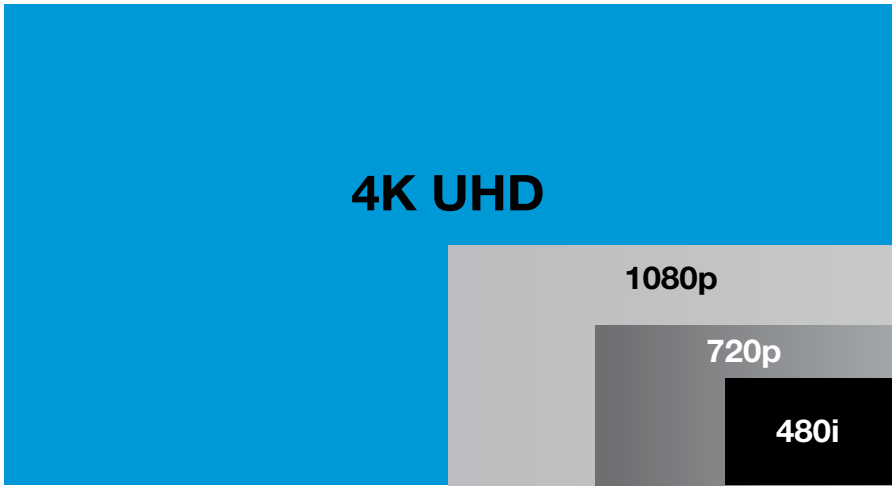


Figure 1.
Comparison of video resolutions.

There are also an increasing number of “tweener” devices that fall between 1080p and 4K resolution. Even if a given system is not being designed for 4K content, hardware designed for 2K signals will not carry these higher resolutions. Therefore, the principles in this document must be applied in any system that might encounter resolutions such as those shown in Figure 2.

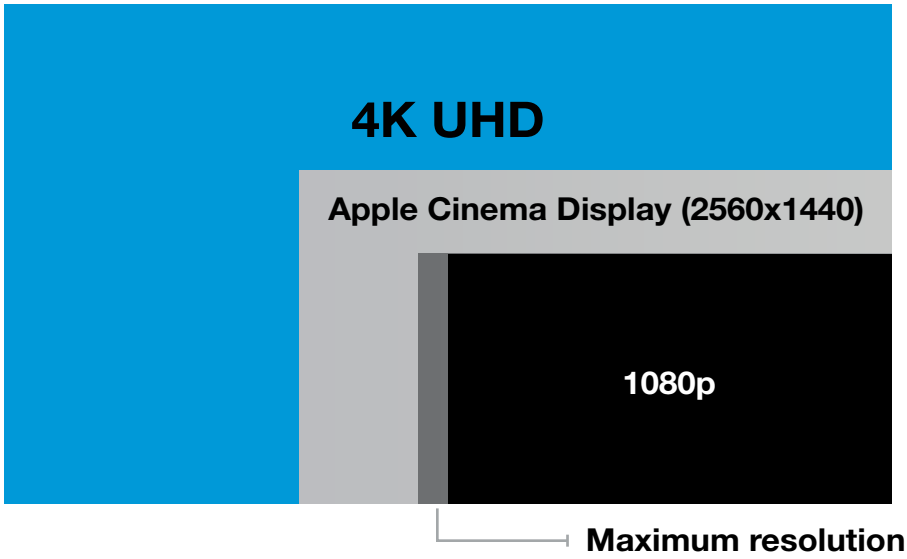


Figure 2.
Common “tweener” resolutions.

Challenge #1: Mismatched resolutions

720p, 1080i, and 1080p video all share the same aspect ratio – 1.78:1 (16:9). Since essentially all sources and displays have used this aspect ratio, we've seen an era of relative simplicity. There's been no need to make accommodations for various aspect ratios for a number of years. With 4K, that all changes because it presents the challenge of managing two different standard resolutions.

Resolution	Aspect Ratio	Common Name
3840×2160	1.78:1 (16:9)	Ultra HD
4096×2160	1.90:1 (~17:9)	4K DCI (Digital Cinema Initiatives)

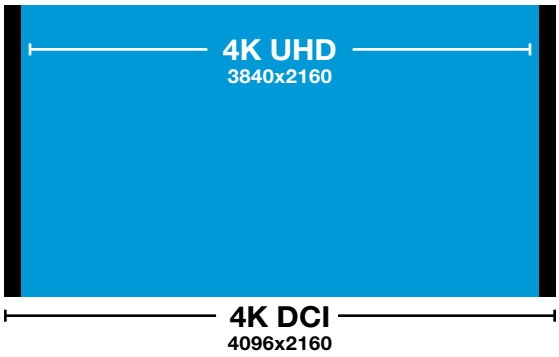


Figure 3.
4K resolutions.

3840×2160 , commonly referred to as Ultra HD, is precisely four times the resolution of 1080p, resulting from doubling both the horizontal and vertical pixel count of 1920×1080. Therefore, it has the same aspect ratio as HD – 16:9. Most, but not all, 4K display devices have a native resolution of 3840×2160.

4096×2160, commonly referred to as 4K DCI, is used in movie production and exhibition in commercial cineplexes. There are some display devices with a native resolution of 4096×2160, but it is not as common as 3840×2160.

Many 4K cameras and source devices can be set to either of the two resolutions. Veteran AV professionals will recall the SXGA computer resolution of 1280×1024, which had a non-standard aspect ratio of 5:4 when nearly every other signal was 4:3. This led to similar problems – displays and sources had to be carefully matched and correctly configured in order to display all of the information without unwanted cropping or stretching.

Challenge #2: New frame rate considerations

To deliver 1920×1080 video at 60 frames per second requires a data rate of 4.46 Gbit/s. It therefore stands to reason that a 4x increase in pixels would increase the required data rate by a factor of four. However, the highest broadly accepted version of HDMI®, 1.4, supports a maximum data rate of 10.2 Gbit/s including overhead.

Therefore, today's 4K devices are limited to 30 frames per second or less. For film, this doesn't represent a change, as the original source material is 24 frames per second. However, for video and computer applications, it's important to note that the frame rate is reduced by half. Therefore, the challenge now is to design systems that may need to manage content at 24, 25, 30, 50, and 60 frames per second.

It's worth noting that technology known as chroma subsampling can enable the transmission of 4K video at 60 frames per second at under 9 Gbit/s by compressing color information to 4:2:0. Note that 4:2:0 is the chroma encoding used on Blu-ray Discs®. Chroma subsampling transmits luminance information at full resolution and chrominance at a lower resolution (in this case 1920×1080). Because the human eye has lower acuity for color differences than for luminance, this optimizes for the best perceived image from the available bandwidth. It remains to be seen if this technology will be embraced by display and source manufacturers. DigitalMedia supports the transmission of 4K content at 50 or 60 frames per second with 4:2:0 chroma subsampling.

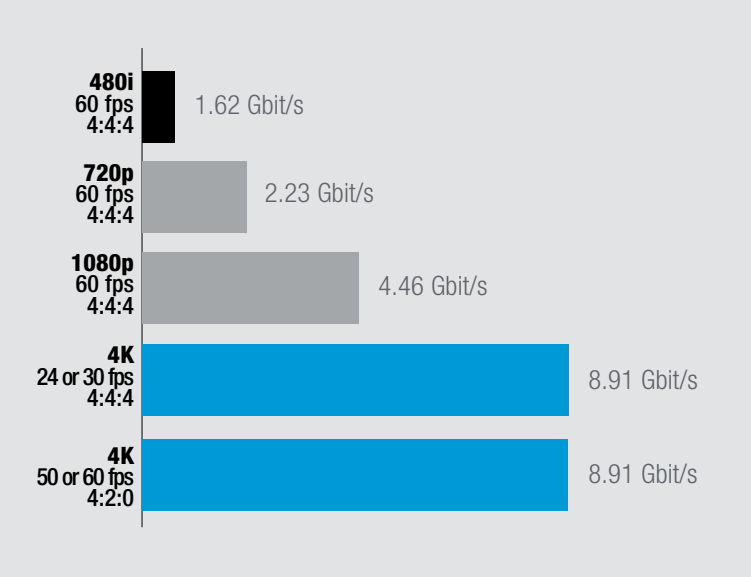


Figure 4.
Required data rates, including HDMI overhead.

DigitalMedia supports the full bandwidth of all formats introduced in HDMI 1.4, as well as 4K at 50 or 60 frames per second with 4:2:0 chroma subsampling, which is a format introduced in HDMI 2.0.

Chroma Encoding	4K - 24 or 30 fps	4K - 50 or 60 fps	HDMI spec
4:4:4	Yes	No	1.4
4:2:0	Yes	Yes	2.0

HDMI 2.0 is still a young ecosystem, as the specification was ratified in September 2013. The chips required for distribution of higher bandwidth HDMI 2.0 formats such as 4K60 4:4:4 content are not yet commercially available.

Challenge #3: Signal integrity issues

Another challenge systems designers must contend with is that signal integrity requirements for 4K video are significantly higher than those of HD. In the test examples that follow we used state of the art test equipment, such as Agilent 12 GHz high performance oscilloscopes, and standard commercially available sources and displays.

Figure 5 shows a clean 1080p eye diagram. The eye is wide open because the system under test has more than enough bandwidth to support 1080p.

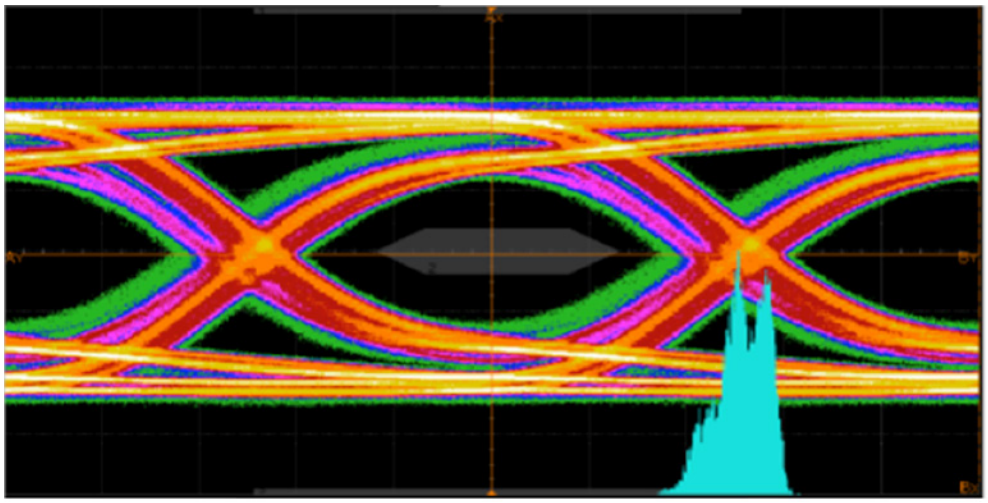


Figure 5. 1920×1080 60 fps video, results as seen at the sink (display device) end of a 3-foot HDMI cable.

In Figure 6, the source resolution is increased to 4K. The rest of the setup remains the same. Notice that the eye closes significantly due to jitter, which is indicated in the teal histogram.

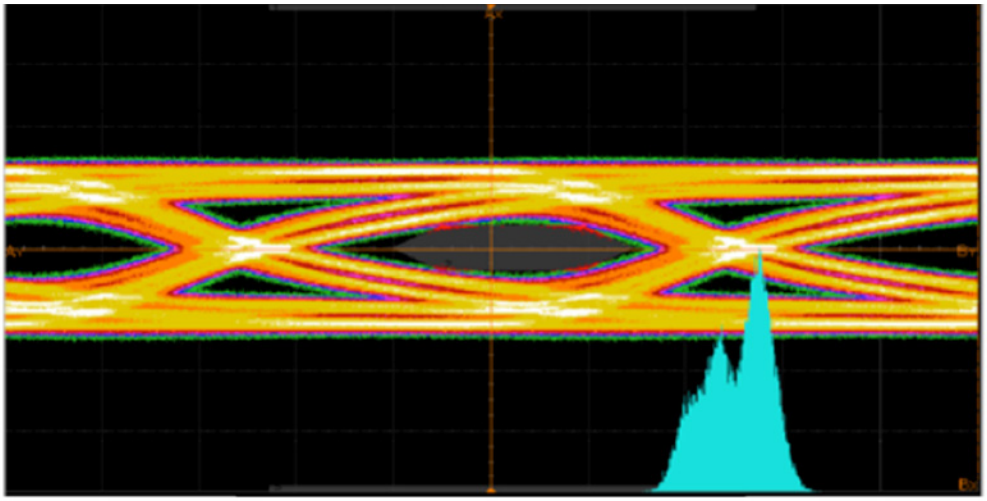


Figure 6.
3840×2160 30 fps video, results as seen at the sink (display device) end of a 3-foot HDMI cable.

In Figure 7, the cable is lengthened to 30-feet. Notice that the eye has closed even further due to added jitter and signal loss. There is significant incursion of the signal into the eye. It is unlikely that this system will work.

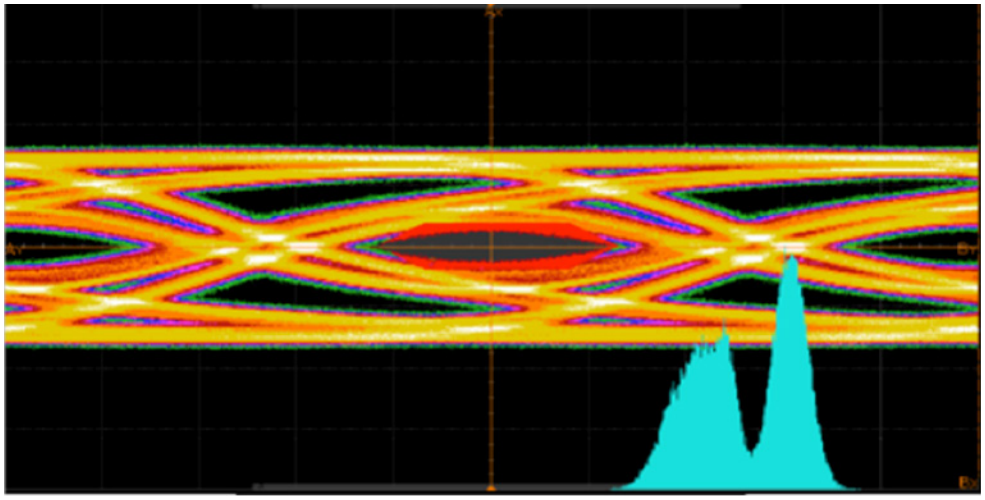


Figure 7.
3840×2160 30 fps video, results as seen at the sink (display device) end of a 30-foot HDMI cable.

In Figure 8, Crestron DigitalMedia is used to transmit the same 4K source 30 feet. Due to output pre-emphasis and other performance enhancements, the result is a much improved eye diagram. Notice that the eye has opened, evidence that the DM system has compensated for signal degradation. DigitalMedia provides the best signal possible. Note that the jitter has essentially been eliminated as indicated by the tight teal histogram.

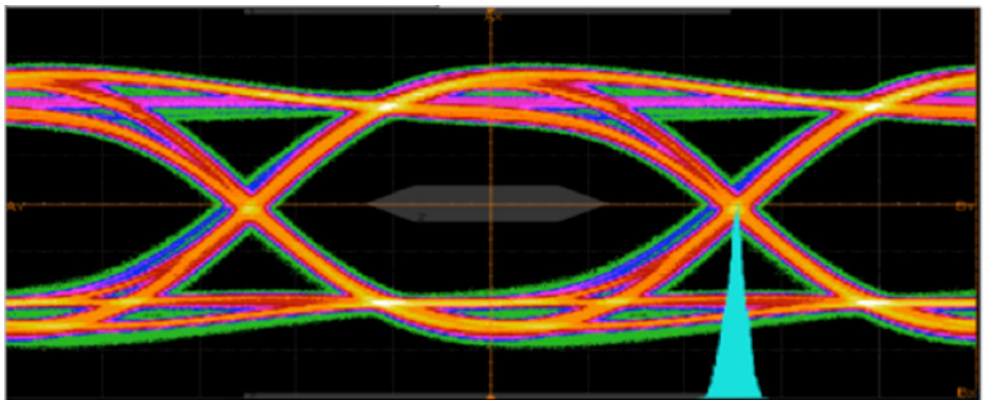


Figure 8.
3840×2160 30 fps video results as seen at the sink (display device) end of a 30-foot cable from DigitalMedia.

In fact, the improvements are so significant that the 4K signal through the 30-foot cable shown in Figure 8 is markedly better than the 1080p signal through the 3-foot HDMI cable shown in Figure 5.

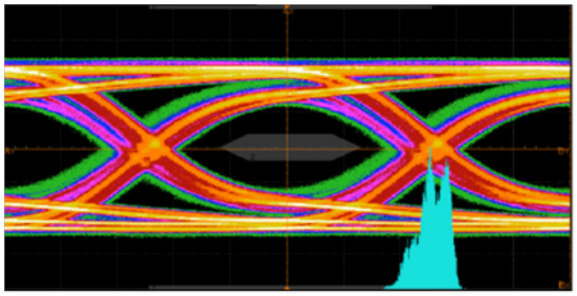


Figure 5.

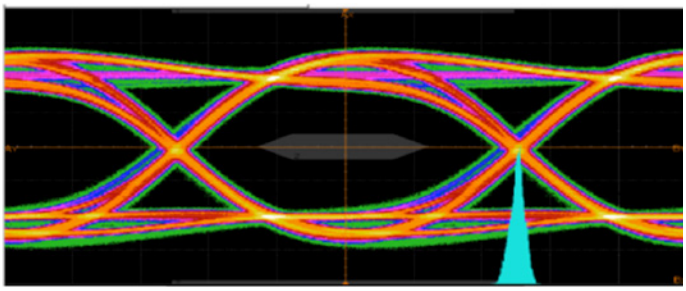


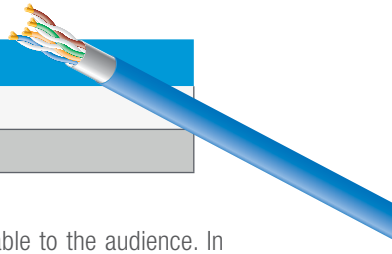
Figure 8.

Challenge #4: New cable length restrictions

Crestron DigitalMedia enables the distribution of audio, video, and control signals over twisted-pair copper and fiber optic cable, together with streaming on a single platform. The first infrastructure type to support 4K is twisted-pair copper cable. DigitalMedia transport over copper supports HDBaseT® Alliance specifications for compatibility with other HDBaseT devices and ordinary CAT5e cable.

Even with the reduction in frame rate and possible gains from chroma subsampling, delivering 4K video requires massive bandwidth. Therefore, maximum twisted-pair copper cable lengths are significantly shorter than the industry has become accustomed to with HD video, creating a new challenge for system designers. After significant test time in the DigitalMedia Lab, Crestron DM engineers recommend the following maximum cable lengths:

	1080p	4K
DM 8G® Cable	100 meters / 330 feet	70 meters / 230 feet
Unshielded CAT5e	100 meters / 330 feet	50 meters / 165 feet



In analog systems, an overly long cable run can result in a degraded image that may or may not be acceptable to the audience. In today's digital systems, however, an overly long cable run can result in no picture at all. Worse yet, incompatibilities between sources and displays are exacerbated by long cable runs. Just because some devices test OK with a longer cable run doesn't necessarily mean that every device introduced into the system later will too. In practice, HDMI cable lengths may be more limited at the higher bandwidth required by 4K as well.

Challenge #5: Source/display compatibility

As is common for the innovators that first bring any new technology to market, the companies developing the first 4K sources and displays have a "chicken and egg" quandary on their hands: how do you test for interoperability with other 4K devices when there are so few of them available during the infancy of this technology? As a result, when these new 4K sources and displays enter the market, compatibility between them is often imperfect. There can even be compatibility issues between products from the same company. This presents yet another new challenge for system designers.

Crestron 4K Certification Program

To ensure that installations go smoothly, Crestron has introduced its 4K Certification program. Under this industry-first program, manufacturers submit their 4K sources and displays to Crestron to ensure that they:

- Deliver true 10 Gbit/s data rates to get the signal to its destination
- Interface with DigitalMedia to handle cable lengths found in integrated AV systems
- Work with other 4K products in a DigitalMedia system

Crestron 4K Certification is your guarantee that certified sources and displays meet the demands of a 4K distributed system.

Crestron engineers in the DigitalMedia Lab rigorously test 4K products to ensure they work in our matrix-switched environment. Only those that do are awarded the Crestron 4K Certified logo. Now, finding a database of 4K products you can trust is as simple as visiting **www.crestron.com/4K**.

Application notes

Upgrading an existing DigitalMedia system for 4K

From inception, all card and blade-based DigitalMedia switchers, from 8X8 to 128X128, were built with the necessary bandwidth to support 4K. With DigitalMedia, to deliver end-to-end distribution of 4K video is simply a matter of upgrading cards, blades, transmitters, and receivers to be 4K-capable.

New 4K DigitalMedia components are backward compatible with existing DM products. Non-4K installations can be expanded or partially upgraded with 4K components. And new 4K components can take the place of their predecessors seamlessly. For example, a DM-RMC-4K-100-C can be used in place of a DM-RMC-100-C.

Mixing 4K and non-4K sources and displays

In practice, we're likely to see a mixture of HD and 4K components in integrated systems for some time to come.

When mixing 4K and non-4K sources in a system, it's imperative to ensure that the transmitter and input cards or blades for the 4K inputs support 4K. It's not necessary to upgrade cards or blades assigned to non-4K sources. Output cards or blades and receivers for the outputs that will carry 4K (including 4K that will be downscaled for an HD display) must be upgraded. If it's necessary to view 4K sources on non-4K displays, a 4K-capable scaler on each non-4K output is required to enable downscaling. If it's not necessary to view 4K sources on non-4K displays, provisions should be made in the control system programming to prevent routing of 4K sources to non-4K outputs.

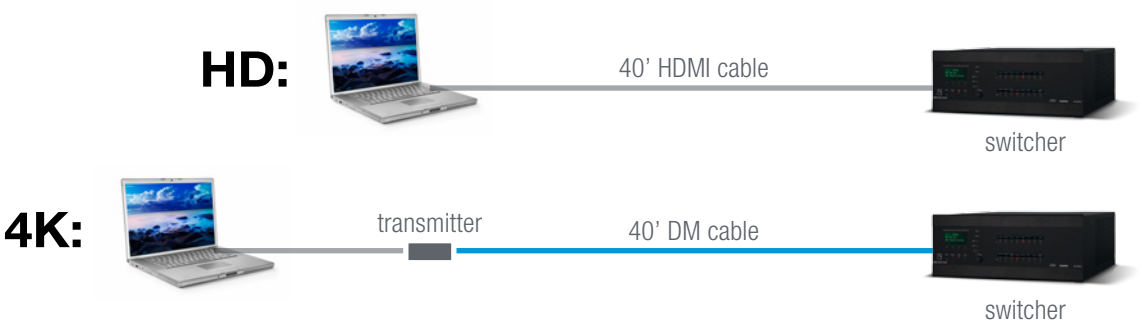
To add...	Required 4K upgrades
4K source	Transmitter Input card/blade
4K display	Output card/blade Receiver
Support for downscaled 4K content to a HD display	Output card/blade Receiver with scaler

Downscaling for non-4K displays

Scalers have proven to be critical components of DigitalMedia distribution systems for years. They've enabled instant switching, eliminated flickering and "no source" messages on displays, made video walls out of ordinary televisions, and ensured that even old SD sources look their best on HD displays. In a 4K distribution system, however, the most important application of scaling is likely to be downscaling. Inevitably, HD displays will remain part of video distribution systems for several possible reasons: they were already in place; they have a more budget-friendly price point; and some applications require smaller display sizes. Therefore, clients will require their new 4K sources to be viewable on all HD displays, not just 4K displays. There will also be other components such as AVRs and surround sound processors that don't support 4K. A DigitalMedia system solves these issues by employing scalers on outputs to convert 4K sources to match the capabilities of each display or other device. All local HDMI outputs on DigitalMedia 4K switchers will include scalers. Scalers will be optional in receivers and other modular products.

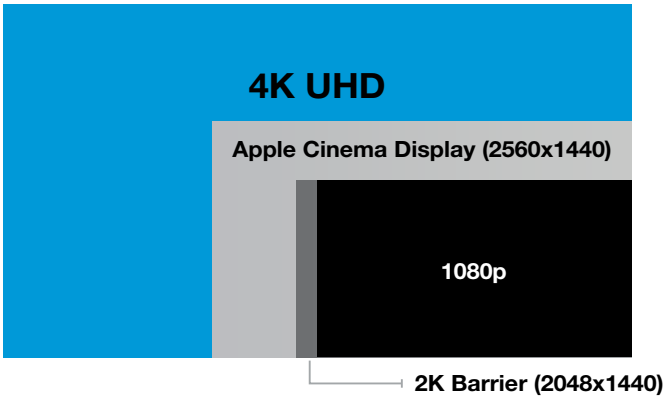
Extenders required more often

Due to shorter maximum cable lengths, extenders may be needed more often. Consider an installation that needs an HDMI cable 40 feet long. At 1080p, this can quite commonly be handled with a passive cable. At 4K, an extender is probably necessary.



Mind the 2K-4K "tweeners"

The resolution of displays built into many devices, including all Apple® Retina® display products and many new laptop PCs, falls somewhere between 2K and 4K. While not marketed by their manufacturers as "4K", these "tweener" devices still require the additional bandwidth provided by 4K-capable switching products to output at native resolutions such as 2560×1600. Computers with high-resolution displays such as Apple Cinema Display® at 2560×1440 also require this bandwidth if their video output is routed through a distribution system. When designing distribution systems be sure they can support the full spectrum of resolutions of today's tablets and laptops.



Conclusion

The many possible combinations of currently available sources and displays present challenges in managing 4K in a large and complex distribution environment. System designers and integrators must carefully consider the systems they are assembling to provide a good end user experience. Before you select an HDMI distribution system, it's essential to fully understand the capabilities of the solution and identify limitations.

It's now more critical than ever that system designers use components they can rely upon. Only by meeting and passing the rigorous testing of the Crestron 4K Certification program can a source or display prove its place in a 4K distribution system. Combining low-cost extenders and other uncertified peripherals will compromise the integrity of a system.

It's easy to make assumptions based on years of experience with SD and HD systems that simply don't hold true in the 4K landscape. For example, when specifying a set of 4K sources and displays it may seem logical to assume that they can all interoperate in an integrated system. However, it may not be true if the sources and displays have not been certified by Crestron.

Furthermore, most 4K switchers cannot provide downscaling of 4K content for non-4K displays or downmixing of multichannel audio for stereo zones. It's critical to have a detailed spec of the switch and to be very careful to make sure that the digital solution you request or purchase meets all of your requirements.

Challenges of Distributing 4K Video

The Crestron DigitalMedia product line was designed to be the best digital transport network for video and audio signals. Thousands of hours of engineering and design were invested in building a system that eliminates the complexities of mixing various high-definition resolutions and 4K video together with audio in one system. The end result is a distribution network that can reliably deliver seamless distribution of the amazing image quality promised by 4K from sources such as laptops, Blu-ray Disc players, and 4K media players to outputs that include both HD and 4K displays. Make sure the solution includes all of the following:

Backing by a source and display certification program so you don't just hope it works, you know it works	✔
Scaling of SD and HD source up to 4K	✔
Scaling of 4K sources down to HD	✔
Instantaneous switching	✔
Scalable zoom feature to enable video wall capability ranging from 2×2 to 8×8	✔
Certification by the HDBaseT Alliance	✔
DSP downmixing (transmits multichannel audio stream and a 2-channel downmix of the same source at the same time)	✔
Use of EDID to automatically select the correct audio track	✔
Support for breakaway audio switching	✔

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