APANTAC
WHITE PAPER

KVM over IP Matrices
for Broadcast Applications

MICHEL RUDELLE

EMEA Regional Manager

Introduction

The need for KVM extension and switching solutions in the Broadcast industry came along-side the use of computers in all aspects of content creation, editing, storage, distribution, etc. Over the years, an ever-increasing percentage of "tasks" were accomplished with software running on computers instead of using dedicated equipment.

With dedicated hardware equipment, the control surface is usually installed in the operator's room while the equipment chassis is in the technical room. The need for having the "computer control surface" or console along with keyboard, mouse and monitor remote from the user follows the same logic; keep the computer chassis (with its fan noise and heat) away from the user.

KVM extenders or point-to-point extension of the computer console were the first devices available, and KVM matrices, which allow the user to assign any computer to any console came afterwards. This brought a new set of challenges compared to simple extension solutions; a KVM matrix may potentially be connected to computers with different resolutions, frame rates, video interfaces (VGA, DVI, HDMI, DP), keyboard and mouse protocols and will (most of the time) have to switch them to identical consoles.

Underlying KVM extension and matrices technology has been evolving over time. Early extenders used simple amplification techniques of analog or digital video signals as well as low bandwidth USB 1.1 keyboard and mouse extension over CATx cables. Maximum distance was a few tens of meters. This simple technology was sensitive to electrical and electromagnetic disturbances. Adding some form of encoding and/or compression to the video has allowed distances to increase. For even further distances, the use of fiber allows extension up to about 10 Km over a single mode fiber.

With respect to matrices, the typical architecture is based on the use of a chassis with a fixed number of RJ45 or fiber ports connecting to computer interface modules on one side and to console interface modules on the other side that use the same extension technology. One challenge with some implementations is scalability. You may be tempted to choose a larger than needed chassis size to cope with a future system size increase. Alternately, if you need to add more computers or consoles over time, and you exceed the number of available ports, you will need to replace the existing chassis with a bigger model with other solutions, or cascade with another chassis.

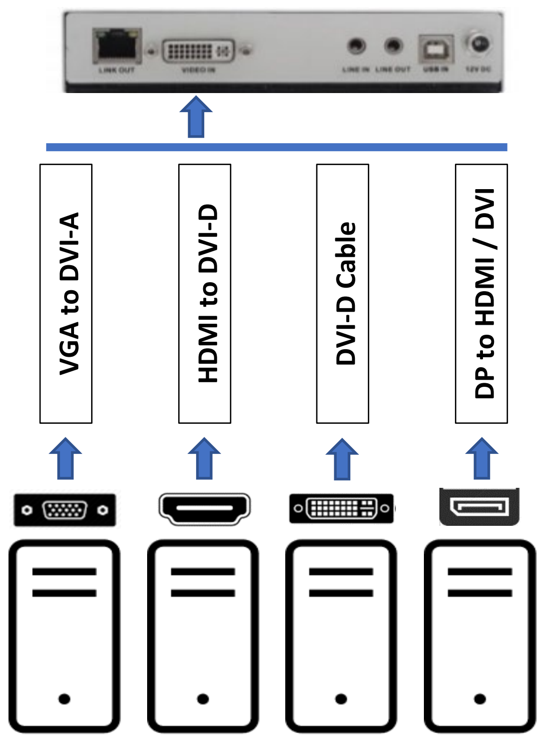
IP technology and its adoption within the Broadcast environment has been a game changer for KVM technology. It brings significant advantages in terms of architecture flexibility and capabilities over traditional approaches. The same KVM transmitters (Tx) and KVM Receivers (Rx) accomplish point-to-point (Unicast) extension with a direct CATx cable / over a network or connect one-to-many / many-to-many (Multicast) computers to consoles over a network. Theoretically, this supports an unlimited number of Tx and Rx in a system which, of course depends on the network size. Furthermore, the cost of commodity network switches is far lower than using a proprietary matrix chassis thus bringing the overall system cost down.

The number of available ports can be also increased using widely available switch technology. The switch in a small to medium size system typically represents less than 10% of the overall matrix cost.

Technical and User Aspects

There are many technical and user aspects to consider when deciding on a KVM solution.

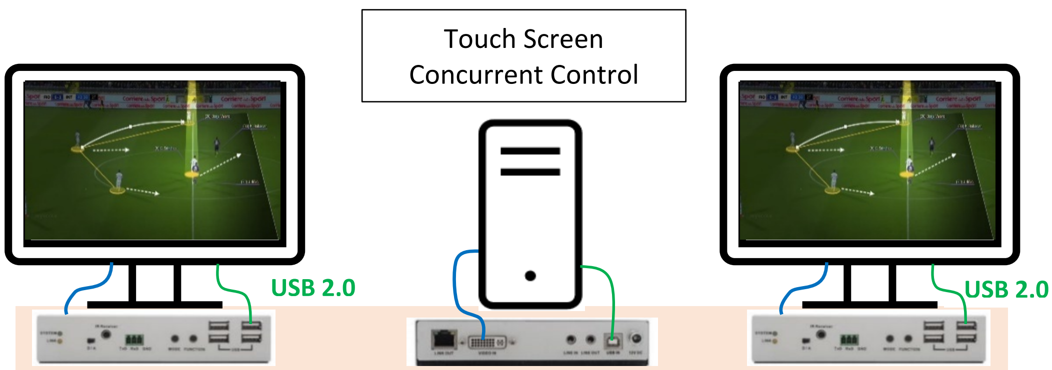
- Computer video interfaces: Current computers include DVI, HDMI or Display Port (DP) outputs, yet many Broadcast facilities still use Windows servers or old computers with VGA outputs that cannot be upgraded to HDMI or DP outputs. In this case having a single Tx module supporting all these interfaces, at least for resolutions up to 1920x1200 is a plus. A DVI-I connector accepts both analog (VGA) and digital (DVI, HDMI and DP) signals via various passive and inexpensive adaptors. HDMI to DVI conversion or the reverse is just a matter of pinout mapping. Most recent computer graphic cards with DP outputs are DP++ compatible. In simple terms this means that the graphics card will output an HDMI signal through the DP connector when "told" by a DP to HDMI adapter. Such Tx modules mix dated and more current computers with different video interfaces in a single system and allow the swap-out of computers with different interfaces without having to procure different Tx units.



- Monitor video interface. Although monitors can have any of the above-mentioned video interfaces, you may want to standardize consoles using a current monitor model with an HDMI interface. However, at least for resolutions up to 1920x1200, having Rx modules with the ability to output HDMI, DVI or VGA may allow users to re-use some existing old but once expensive equipment such as an old VGA projector.

- Keyboard and mouse interface. As its name implies, a KVM extender or matrix must support keyboards and mice in addition to video (as a minimum) even if for some applications video-only Tx modules can be useful. Keyboards and mice on the market today use the USB-HID (Human Interface Device) protocol. However, in the case that older computers are only equipped with a PS/2 keyboard and mouse, support for this protocol must be provided. Some manufacturers provide both USB and PS/2 connectivity on their Tx, and others not. In the latter case, you will need to procure an active USB-HID to PS/2 protocol converter. Most keyboards and mice support both protocols, thus passive adapters with pinout adaptation can be used to control PS/2 computers, but active adapters capable of protocol translation must be used with Tx units that only support USB. These are available from many KVM matrix manufacturers.

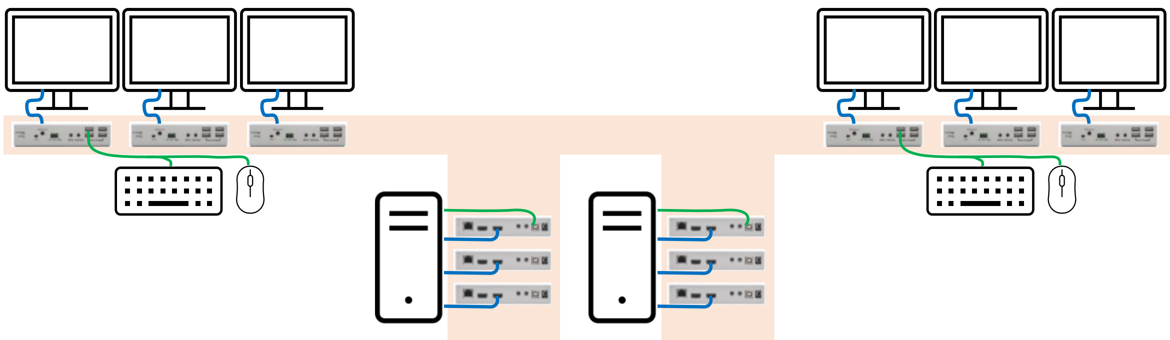
- USB 2.0 support. When available, USB 2.0 is used in extending / switching devices commonly used in Broadcast, such as touch screens. For example: Several journalists interacting via touch screen monitors to comment on a soccer game. Another example: Using a Wacom tablet to control a graphics application or using USB disks to copy content from/to a server. USB is an incredibly complex standard with multiple variants, various communication speeds and the number and types of USB devices is endless; thus it is safer to test your devices carefully if you plan on interfacing with other devices than those listed above.



- Audio. Whether you need to extend the bi-directional "Line Out" & "Mic In" analog stereo pair of a computer in a point-to-point situation or carry the eight embedded audio signals of an HDMI input from a server to listen to in the audio mixing room; these are nice features you may expect from a modern KVM extender / matrix solution.

- RS-232, IR, GPI. With KVM extenders/matrices, connectivity between sources and destinations is a given. Extra capabilities, such as RS-232 for remote controlling equipment using a serial interface is a plus. In some situations, Infrared (IR) for remote controlling a source player using an IR remote control next to the monitor Rx or GPI for propagating a contact closure to a Tx can also be a nice addition.

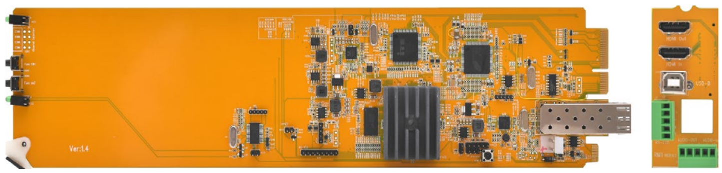
- Multiple heads. Dual-head computers are now very common and even three/four head computers are becoming more commonplace. Some manufacturers propose a dual-head Tx/Rx KVM models in addition to single head KVM Tx / Rx pairs. The advantage to this approach is that you usually use a single CATx cable to connect dual-head Tx/Rx. This however has some drawbacks, as you will need to replace the Tx or the Rx if you decide to turn a single head computer / console into a dual-head version. Furthermore, it is not easy to go beyond two heads. The Apantac approach is to always use single head Tx/Rx models and to have "logical" two, three or four heads versions. For example: to interface a dual-head computer, you will use a main Tx that will transport the video and USB and a slave Tx that will accept the second head video. Functionally, you only switch the main Tx to the main Rx and, if properly configured, the slave Tx/Rx will follow. Up to four heads can be handled that way. This flexible multi-head approach reduces the need for numerous Tx/Rx models.



- **Form factor:** Most of the time, the Tx and the Rx units are compact with an individual external AC/DC adapter. Some manufacturers propose larger units with AC inputs. Power is sometimes supplied via USB, but this relies on the ability of the interfacing device to provide enough power. With KVM over IP, using Power Over Ethernet (POE) is a very efficient way of powering compliant Tx and Rx units. POE switches provide power to the devices over CATx cables in addition to IP connectivity. This technology is widely used in the IT world and is very mature. It removes the need for AC/DC adapters, thus simplifying the installation.

  A clever way to facilitate a Tx and Rx installation is to supply the modules with a magnetic base and an iron mounting plate. On the Rx side, you can screw or stick the mounting plate underneath or inside the desk. On the Tx side the modules can "stick" to any metallic surface, such as the side of racks, tops of servers etc. Units can be pulled out and put back in place very easily without using tie wraps or tape.

When Tx units are gathered in a single rack e.g. a server rack, an even more efficient approach is to use cards instead of individual modules. This has several advantages: Compactness, power supply redundancy, the ability to monitor all the Tx cards from a single GUI (e.g. from Dashboard with the Apantac KVM-IP-Tx openGear cards) and "neat cabling."



- User experience. A user will expect the same experience whether he/she works directly on the computer or remotely. Several aspects must be considered: Picture quality or the ability to display pixel for pixel, the original computer picture, whether the content is static or dynamic, e.g. when playing a clip. Latency is also important; latency corresponds to the time it takes to carry the video from the computer to the console monitor. A simple test is to move the mouse pointer or a window around to "feel" the reaction time on the monitor. Apart from mainly gamers who are sensitive to reaction times, latency is usually not noticeable unless it exceeds 20 milli-seconds.

- Video compression. Solutions without video compression provide the best quality since the remote monitor picture is an exact copy of the local monitor and most of the time there is no latency at all. However, carrying uncompressed signals specifically with UHD/4K resolutions requires significant bandwidth. With KVM over IP technology, this means using 10 GigE instead of 1 GigE networks, which may hinder the cost benefit of this approach. Using a lossless or visually lossless compression algorithm is a good compromise since most users will not notice any difference, and compression / decompression latency can be less than 20 milli-seconds.

- Switching between computers. Another important factor is the switching time between different computers, which is impacted by:
  - Mix of different source resolutions and formats. Even if the actual switching time was zero, it is easy to imagine that a monitor displaying a 2560x1440 resolution may take some time to lock when abruptly switched to a 1024x768 source. Ideally you may want to set all your computers to the same resolution, but it may not always be possible. It is not uncommon in the Broadcast field to find a mix of cutting-edge and old VGA servers with different resolutions.
  - When you connect a monitor to a computer, the computer graphics card reads the monitor EDID table first and automatically adjusts its output resolution based on the content of this table. The EDID table describes the monitor capabilities, such as preferred resolutions, chromaticity, audio parameters etc. With a KVM extender or matrix, the computers read the EDID from the Tx modules, thus allowing some degree of control. There are different ways of handling the EDID e.g. using predefined EDID

tables, electing one monitor to be the "EDID master," or "passthrough" that carries the console monitor EDID to the computer it is switched to etc. The passthrough approach may force the source graphics card to reconfigure itself when it sees console monitors with different EDIDs. It may take 10 seconds or more before you can use the computer in these cases. One of the possible choices is to let the user choose one EDID table in a list with a specific preferred resolution when configuring a Tx. You can then, to the extent that the computers support it, "force" all the computers to output the same resolution, and therefore reduce the switching time. Another nice feature is to have a Rx built-in scaler. When enabled, you can set the scaler output to a fixed resolution or use the console monitor EDID to determine it. As a result, the Rx scaler will accept the various computer resolutions and always scale them to the monitor resolution. Since the console monitor always get the same resolution, the switching time can be kept to a minimum.

- System architecture. With proprietary KVM matrix solutions, chassis ports are available as inputs only (connected to a Tx), outputs only (connected to a Rx), or configurable as inputs or outputs. Chassis may have a fixed size or may be modular. If your system evolves over time, you may face situations where adding one more computer or console may be costly because the existing chassis is full, and you must buy a larger chassis or add a second one. Also, distributed architectures across several buildings may be impossible or only possible at a significant cost. With KVM over IP matrices, the "matrix chassis" is a network based on the use of COTS switches and routers. This technology is mature, affordable, and flexible. It has better scalability, supports well distributed architectures and remote access over the WAN is possible. From the network perspective, the maximum number of Tx and Rx in a system is theoretically unlimited. In practice, other factors are limiting their actual number.

- Security. As soon as IP networks are at stake, security immediately becomes an important concern. The IT industry is now very aware of this and many different strategies and measures are available to prevent hackers from accessing your content and resources. However, small or medium size Broadcast facilities may not have yet the internal skillset to deploy a mix of KVM over IP devices and office computers on a single network. Furthermore, existing office networks may not be designed for the KVM over IP bandwidth requirements and internal IT people may be reluctant to mix all devices on a single network.

  It may be easier and safer to connect all the Tx and Rx to a dedicated network (with switches / routers), thus totally shielding the KVM over IP network from any external interference. The switches / routers setup requires only a few settings. For example: enable IGMP, IGMP Snooping, Jumbo frames and a few other with routers.

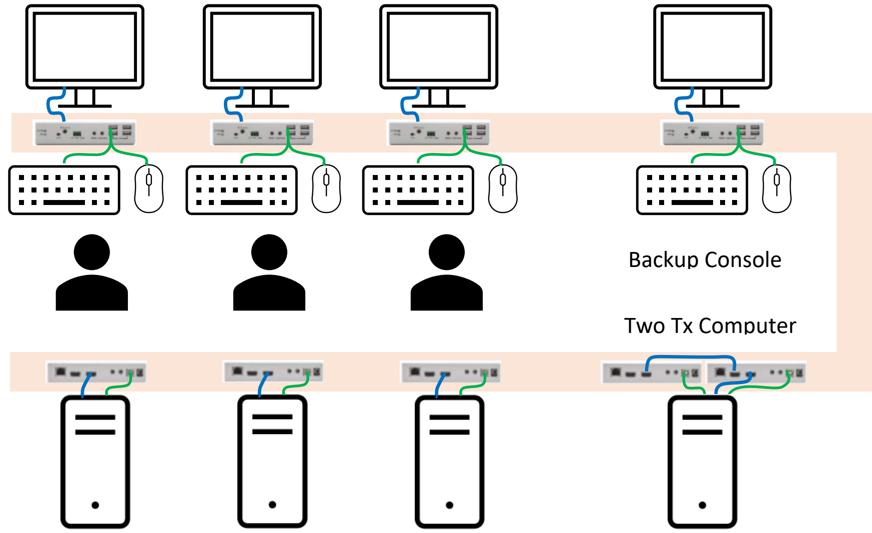
  Of course, large systems with hundreds of Tx and Rx are a different story. In this case, you will not avoid network and network setup complexity and may require external networking expertise to deploy them. For such systems with multiple console positions and users, you will likely look for solutions that define password protected profiles, with logging and alarming capabilities, encrypted transmissions, etc.

One feature you may need when selecting a KVM over IP solution is transparency with HDCP (High-bandwidth Digital Content Protection) protocol. There are basically two mechanisms at play: A constant handshake between the source and the monitor. If the handshake does not happen, the source will stop sending the signal. Then the video content is encrypted, thus de-encryption is happening in the receiving device to display the picture properly. Typical source devices with HDCP protection are Set Top Boxes, Media Players as well as some MAC computers or some recent Windows computers. If your KVM system does not handle HDCP, you will not be able to use them. Certain old monitors do not support HDCP. If one console monitor displays a MAC computer output correctly and the same MAC computer gives a “black screen” on another console, there is a good chance that the latter monitor does not support HDCP.

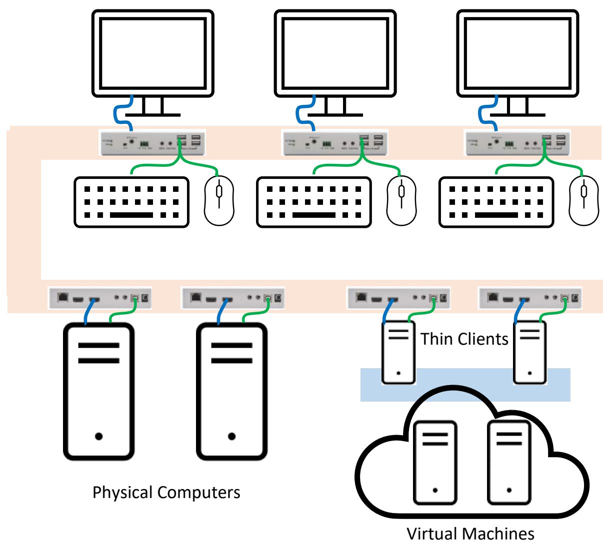
- Redundancy. In theory, each component of a KVM over IP matrix is a potential single piece of failure, thus you may want to consider different strategies depending on the degree of redundancy you look for and the budget you are ready to allocate to it:
  - Computer redundancy. If you use redundant computers working in sync, you will also need two Tx; one for each.
  - Tx redundancy. Some Tx models have an active input loop. A computer can then feed video to two Tx. Each Tx will connect to one USB port of the computer. If one Tx fails, you can switch to the backup Tx.
  - Rx redundancy. You can decide to have one or more consoles in addition to the actual number of users. Should one Rx (or the associated, keyboard, mouse, display) fail, the user can assign the computer he was working on to a spare console. Back up consoles may be configured to follow the main consoles source assignment.
  - Network redundancy. The highest degree of redundancy will require two independent network switches attached to two sets of Tx connected to redundant (or not) computers and Rx attached to each of the two networks.

Some manufacturers also propose Tx and Rx with two IP connections (one to a main and one to a backup network), but these units then become a potential “single point of failure.”

The above discussion is just scratching the surface of the vast topic of redundancy and does not include “automatic failover” mechanisms. However simple things such as adding an extra console or doubling the Tx of a critical computer will address the most common concerns.

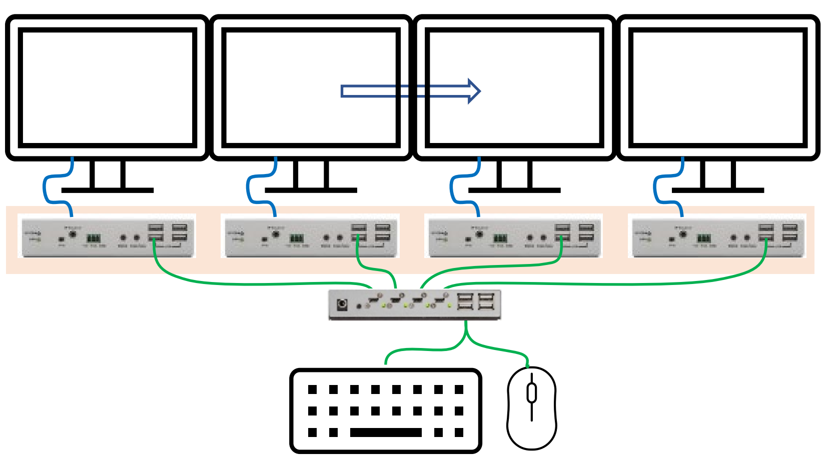


- One recent requirement with KVM over IP systems is the ability to remotely access a mix of "physical" and ["virtual" machines](). Virtual machines are typically accessed via network protocols (RDP, VNC and SSH) by thin clients, which are essentially low performance computers providing a physical user interface to the virtual machines. Some manufacturers propose a dedicated thin client Tx to access any virtual machine that is seen by the user like any other Tx. This is a nice integration but one major concern with this approach is security. This thin client Tx is a computer with two IP interfaces; one to the KVM over IP network and one to the virtual machine IP network. Unless proper security measures are taken this can be a door for hackers to get into your system. Network and computer security require expert knowledge that not all companies are mastering. A simple alternative if you only need to access a few virtual machines would be to connect regular Tx to actual thin clients (see the diagram.) This requires a bit more hardware but will guarantee the proper shield between the two networks. Furthermore, the thin client consoles could be used as local back up consoles.

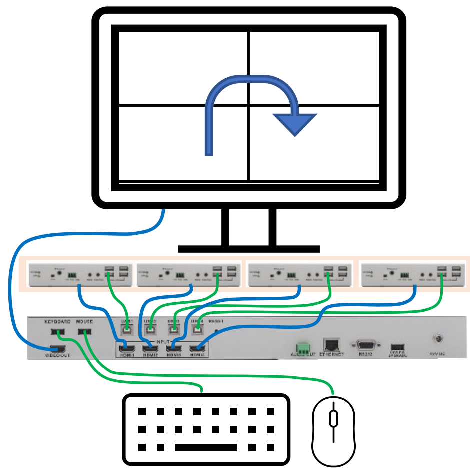


- Usability. Many features will make a difference in terms of ease of use and the implementation and their level of sophistication is dependent on the manufacturer. Here are a few:
    - Keyboard shortcut choice to access the console pop-up menu for choosing which computer to control and much more. This feature is available from all manufacturers.
    - Concurrent access. This is the ability for several consoles (including the local console if present) to access one computer concurrently.
    - Ability to limit the access to only a subset of all the computers from a console, whether it is console specific or login profile specific.
    - Computer application or control panel to assign Tx to Rx. E.g. you may want to disable the computer selection menu of a public area console and assign it to a computer remotely. Another use is to assign sources to "video only consoles." E.g. for feeding a large monitor or projector.
    - Ability to forbid a USB 2.0 connection. On the Tx side for example: avoid copying a USB stick content remotely to a critical server. Or on the Rx side for example: To block the use of USB sticks from a public area console.
    - Ability to assign the console video to another screen or a video wall via the console pop-up menu. E.g. when the user wants to share what he/she sees on his console with colleagues.
    - Ability to define scripts – e.g. several assignments, and to recall them from the console pop-up menu or a control panel.

- Super consoles. With more and more computers to control, a single user may have to "keep an eye" on several computers at a time and gain access to one of them very quickly. The KM switch (Keyboard Mouse USB switch) addresses this need. Instead of facing several keyboard, mouse and monitor sets on the desk, the operator still uses several monitors but a single Keyboard and Mouse. When he/she moves the mouse cursor on a computer display to the edge, it "jumps" to the next monitor and then controls the corresponding computer. The hardware implementation uses a USB switch that can be used with KVM consoles or directly with computers. With some KVM matrices, this functionality is implemented in software.



An even more flexible approach is to connect the Rx console video outputs to the inputs of a multiviewer with built-in KVM capability. The functionality is the same as above, but the physical console monitors are replaced by resizable and repositionable PIPs (picture in picture) on a single large monitor. Different PIP layouts including full screen can be created and recalled. At Apantac, we have several multiviewer models with HDMI 2.0, UHD / 4K resolution inputs and outputs with built-in KVM capability that are a perfect fit for these applications.



- Video Wall. Control rooms make great use of both KVM matrices and Video Walls. Broadcast facilities also use video walls for various purposes; in the facility lobby for promotion purposes, in a newsroom, as a studio backdrop, etc. Apantac Rx models feature a built-in scaler. This scaler can be used to turn each Rx into one "brick of the wall." The concept is simple; each Rx that feeds one monitor of the wall gets the same video stream and is told (via configuration), which part of the picture to display. All the Rx of a wall are synchronised, thus avoiding picture breaks when there is motion in the content. The image can also be displayed in landscape or portrait mode allowing Video Walls with unusual shapes. The wall can be controlled via a dedicated application that creates several layouts, which can be recalled manually or automated. Alternatively, a console operator can duplicate the console monitor picture in full screen to the wall via the console pop-up menu.

In Summary

Apantac's KVM solution addresses most of the features described in this paper and is a good fit for small and medium size Broadcast facilities (including OB Vans) looking for a high quality, feature-rich, cost effective and simple to deploy KVM over IP solution.

More details can be found in this presentation. This video gives a good overview of several features.

APANTAC

Contact Information

HEADQUARTERS

10200 SW Allen Blvd Suite C
Beaverton, OR 97005. USA

T: +1 503 968 3000
F: +1 503 389 7921
E: info@apantac.com

US WEST

T: +1 714 815 7421
F: +1 714 879 3079
E: Bill.Gray@apantac.com

US EAST

T: +1 814 238 2365
M: +1 814 753 0000
E: Dave.Campbell@apantac.com

NORTH ASIA

T: +1 503 968 3000
E: APAC_sales@apantac.com

EMEA

T: +33 6 2483 0742
E: Michel.Rudelle@apantac.com
Skype: michel-rudelle

LATAM

T: +52 55 10108292
F: +1 503 389 7921
E: edgar.flores@apantac.com

ASEAN

T: +65 9006 1497
F: +1 503 389 7921
E: aniket.rangnekar@apantac.com
Skype: aniketr.sg

CHINA

T: +86 10 8795 5211
M: +86 1391 093 0624
E: Jumping.Zhao@apantac.com

JAPAN

T: +81 90 1843 7628
E: Hiroo.Sasaki@apantac.com

ABOUT US

Apantac is a leading designer and developer of high quality and cost effective multiviewers, video walls, matrices, extenders, and signal processing equipment.

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