BLACK BOX
NETWORK SERVICES

HD Video and Peripheral Matrix Switching and Extension

An overview of extension and switching technologies in high-performance KVM environments.

- Effective management of broadcast, air traffic control, control rooms, and other collaborative environments.
- Flexible control of visual and peripheral elements.
- Real-time, instant switching and display of HD video and peripherals.

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We're here to help! If you have any questions about your application, our products, or this white paper, contact Black Box Tech Support at **724-746-5500** or go to **blackbox.com** and click on "Talk to Black Box." You'll be live with one of our technical experts in less than 30 seconds.

Introduction

Considering the many available extension and switching solutions might seem like an overwhelming task. But taking some time to research and understand your options will be well worth the investment. Whether your application is digital high-definition video, KVM, or matrix peripheral switching, using extenders enables you to remove computer noise and heat from your work area.

The current four trends in control and monitoring solutions are:

- An increase in digital switching applications.
- An increase in digital video distribution applications.
- A desire for flexibility in controlling visual and peripheral elements.
- A requirement to simplify complex system designs and increase functionality.

About Black Box

Black Box Network Services is a leading KVM, HD video and peripheral matrix switching and extension solutions provider, serving 175,000 clients in 150 countries with 200 offices throughout the world. Black Box is also known as the world's largest technical services company dedicated to designing, building, and maintaining today's complicated data and voice infrastructure systems.

Becoming Ergonomic

All control applications serve one purpose: to help people focus on the applications and processes of their jobs. Ergonomics, or the science of adapting the job and/or equipment and the operator to each other for optimal safety and productivity[1], is the end goal.

Ergonomics is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system. The science of designing user interaction with equipment and work places to fit the user has been the cornerstone of technological advances in automation and computer-based systems.

The key elements of ergonomics are silence, a comfortable room climate, flexibility, scalability, service friendliness, and ease of use.

1. Silence and room climate:

- Remove noisy equipment from the operator's desk.
- Keep heaters out of the room.
- Backrack servers in environmentally friendly environments.

Results will enable the operator to focus more closely on his or her work, rather than on the equipment affecting his/her work. Taking these steps ensures a rich desktop experience. However, you have to be careful to not sacrifice signal quality when bridging the distance between the operator and the equipment.

2. Flexibility and scalability means equipment should:

- Enable relocation and backups easily.
- Leave room for expansion.
- Be able to share systems, signals, and resources.

3. Ease of use and service:

- Enable easy control, steering, and operation.
- Create no technical overhead.
- Keep service and maintenance out of sight of operators.

Extension Basics

Modern digital extension and switching technology emphasizes the movement from analog to digital video, and also away from fixed-user-to-computer KVM switching toward nearly freely scalable matrices (matrix switching). These new proprietary (using CATx or fiber optic cables) and IP-based digital technologies offer real-time solutions— no delay, no skew. Along with extending digital video, these applications extend keyboard and mouse, digital or analog audio, serial, and USB.

Additionally, the designs that apply to the technologies outlined in this white paper provide a quieter workplace and remove excess heat from the area by placing computers in low-dust, climate-controlled equipment rooms without sacrificing video quality, picture resolution, or real-time switching of peripherals. Finally, server maintenance, software updates, and network administration become centralized, plus time and cost associated with support is reduced.

1. http://www.osha.gov/SLTC/ergonomics/

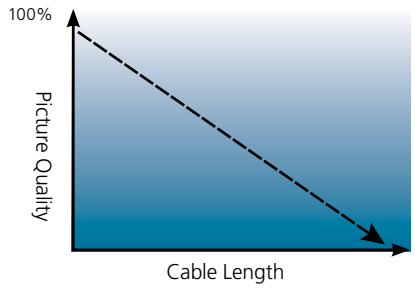
Analog versus Digital Video

Analog video (VGA)

An analog signal is continuously variable. Composite video, Component video, RGBHV, and VGA are types of analog video signals, with VGA being the most common video format used with PCs—at least until recently.

An analog video signal can be run over long lengths of native VGA cable as long as the diameter and shielding of the cable is good enough. However, regardless of the cable quality, signal attenuation increases with video frequency and cable length. This means that after 30 to 50 feet, the image quality will start to degrade. This leads to color skew and smeared-looking text.

To solve for signal degradation in VGA applications, use an extender that compensates for signal loss. A good extender has separate adjustments for high and low frequencies; HF loss is usually greater than LF loss.

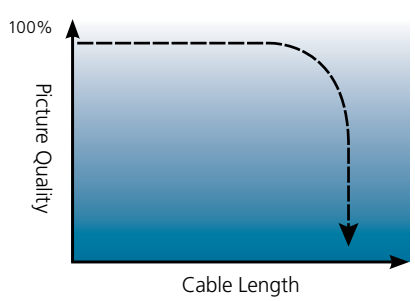


Picture quality of an analog signal gradually declines over longer lengths of cable.

Digital video

While analog video signals travel in a sine-like wave form, digital signals travel in a square-like waveform. A digital signal is broken into a binary format where the audio or video data is represented by a series of 1s and 0s. Like analog signals, digital video also suffers from loss, but as long as the cable is of sufficient quality and within the maximum supported distance, the signals don't suffer from blurring or color skew. HDMI and DVI (explained below) are examples of typical digital video interfaces.

However, what you will get when the maximum supported cable length is exceeded is the "cliff" effect, where the digital signal drops off and you completely lose the picture. To overcome distance limitations, you need to use extenders or repeaters.



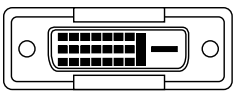
Picture quality of an digital signal (e.g. HDMI) suddenly drops at a certain length of cable. (cliff effect)

DVI and HDMI Interfaces

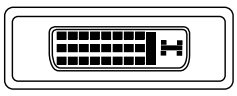
Digital video interface (DVI)

DVI is the standard digital interface for PCs.

The DVI standard is based on transition-minimized differential signaling (TMDS). DVI comes in two formats: single-link and dual-link. Single-link DVI has a maximum frequency of 165 MHz, and dual-link DVI, as you would expect, has double the maximum frequency. A single-link interface can transmit a resolution of 1920 x 1200 vs. 2560 x 1600 for dual link.



DVI-D Receptacle Connector

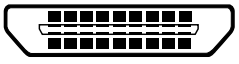


DVI-I Receptacle Connector

The most common DVI connectors are:

- DVI-D: A digital-only connector for use between a digital video source and monitors. DVI-D eliminates the analog pins.
- DVI-I (integrated): Supports both digital and analog RGB connections. It can transmit either a digital-to-digital signal or an analog-to-analog signal. It is used on products instead of separate analog and digital connectors.

High-definition multimedia interface (HDMI)



HDMI® is the standard digital interface for HDTV. It was the first digital interface to combine uncompressed HD video, up to eight channels of uncompressed digital audio, and intelligent format and command data in a single cable. It is now the de facto standard for consumer electronics and HD video, although it is beginning to face competition from the newer DisplayPort (DP) interface. In addition, HDMI also uses TMDS signaling, like DVI, and is backward compatible.

HDMI offers an easy, standardized way to set up AV equipment over one cable. Use it to connect equipment such as digital signage players, set-top boxes, and AV receivers with HDTVs and video projectors. If the HDMI equipment supports higher-resolution HDMI standards, you can also connect 3D displays.

HDMI also supports multiple audio formats from standard stereo to multichannel surround sound. In addition, the interface provides two-way communications between the video source and HDTV, enabling simple, remote, point-and-click configurations.

It also supports high-bandwidth digital content protection (HDCP), which prevents distribution and copying of digital audio and video content sent over HDMI cable. If you have a device between the source and the display that supports HDMI but not HDCP, your transmission won't work if the content is copyright protected.

HDMI is backward compatible with DVI equipment because, like DVI, it uses TMDS signaling. A DVI-to-HDMI adapter can be used without a loss of video quality to enable the connection. Because DVI only supports video signals, not audio, the DVI device simply ignores the extra audio data. However, dual link is not common in HDMI. DVI displays usually also are not able to display HDCP protected and/or component encoded (YCbCr) HDMI signals.

Technical Aspects of Digital Video Extension

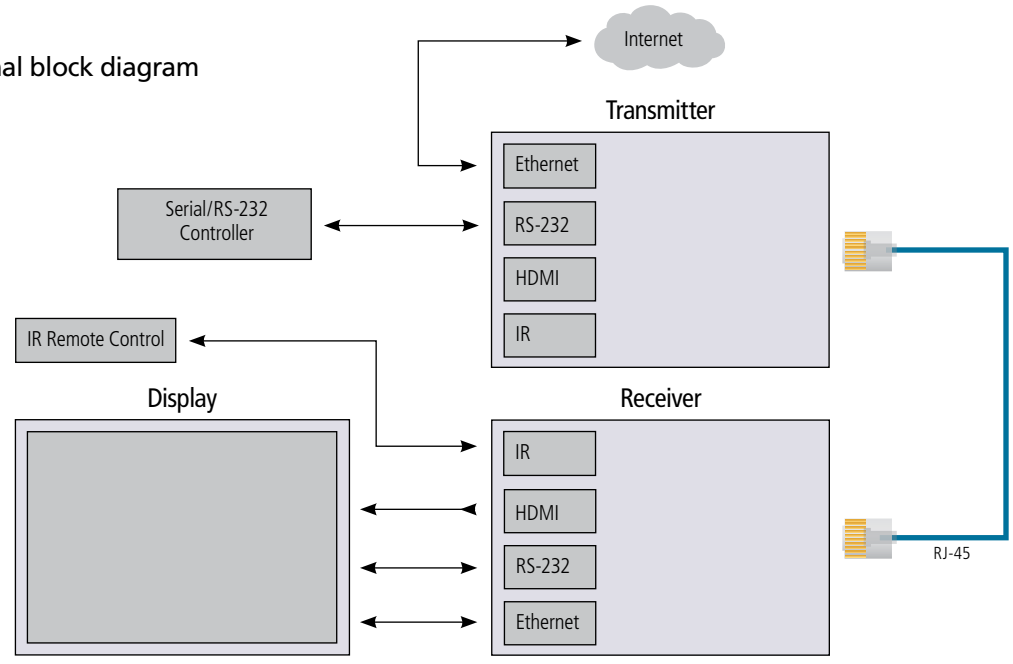
Lossless proprietary extension

When the TMDS signal collapses because of attenuation, or too long a cable, it is no longer readable by a display. However, an extender or repeater uses a proprietary digital algorithm to transmit and receive signals over a specific distance, and can equalize and reshape the TMDS signal for the end display. Proprietary extension technology enables users to extend HDMI or DVI to a remote display up to 100-120 feet away without any loss or signal degradation. Extension is possible over native HDMI or DVI cabling with a repeater device equalizing the signal, or over CATx with an extender setup that consists of transmitter and receiver device.

HDBaseT extension

HDBaseT™ is the first technology to enable long-reach wired connectivity of uncompressed HD multimedia content via a single LAN cable. HDBaseT enables transmission of DVI or HDMI video and audio, 100BASE-T Ethernet, power, and control signals from a source to display over a standard CATx cable. By using sophisticated encoding and equalization techniques, it is possible to transmit the video signal as well as the peripheral signals uncompressed up to 330 feet (100 m). The chip has proven to be very reliable and is the only solution on the market today allowing transmission of uncompressed video on standard CATx cables at that distance.

HDBaseT functional block diagram



Compressed digital extension and IP extension

Another technique to extend video over longer distances using reduced bandwidth is to use compression. Compression makes it possible to run the signal over longer-distance cable, up to 400 feet (120 m); to transmit it wirelessly; or to send it over a standard IP network, the local area network (LAN).

Compression does not have to mean low-quality video. Compressions may be lossy or lossless. The compressions used on cable TV or Internet video streams are usually lossy compressions, such as H.264. Although these compressions give sufficient image quality for digital signal, they are not suitable for high-quality computer images in control rooms or medical applications. These applications require higher bandwidth but usually run over a LAN where bandwidth is not an issue, not over the Internet. The best compression algorithms today make it possible to run Full HD computer images and video over the local network without any visual loss in quality.

IP extension is a way to extend your application over long distances. IP extension is flexible and expandable, and gives you the option of using either CATx or fiber optic cabling, depending how far you want to go. IP-based extenders usually send data over a 330-foot (100-m) segment, but you can extend farther by using Ethernet switches as repeaters; or, if using fiber cable, go even farther, up to 10 miles (16 km).

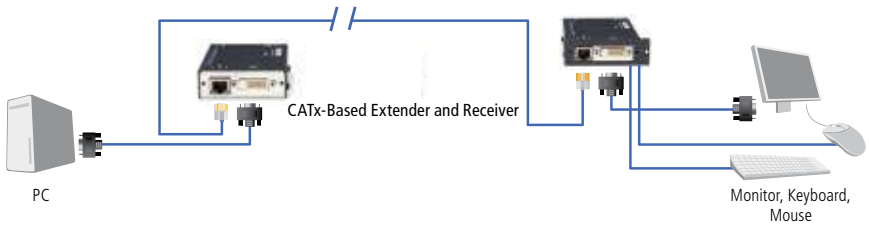
Lossy to lossless compression.

Fiber optic extension

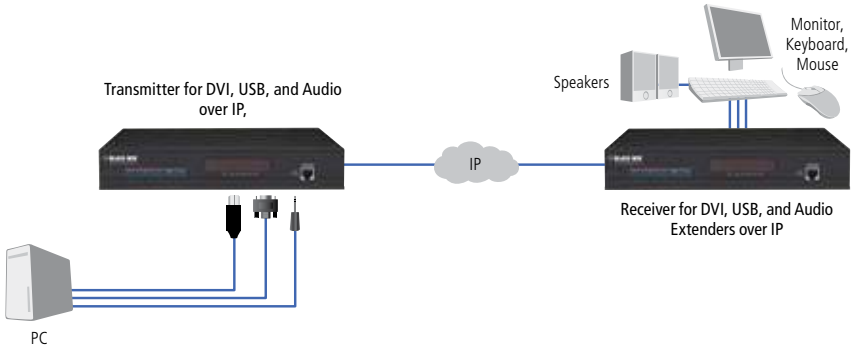
For the really long runs exceeding 400 feet (120 m), the best option is fiber optic extension, unless you can use multiple repeaters or run the signal over an IP network. The biggest advantage with optical extension is the very high bandwidth compared to copper cable. This makes it possible to transmit lossless, full HD signals over great distances—up to thousands of feet. Furthermore, using a fiber cable makes the connection optically isolated, getting rid of any issues with ground loops, etc. This is usually required in hospitals and other critical applications. An optical connection is also immune to EMI noise, making it the perfect choice for industrial applications.

Digital extension technologies

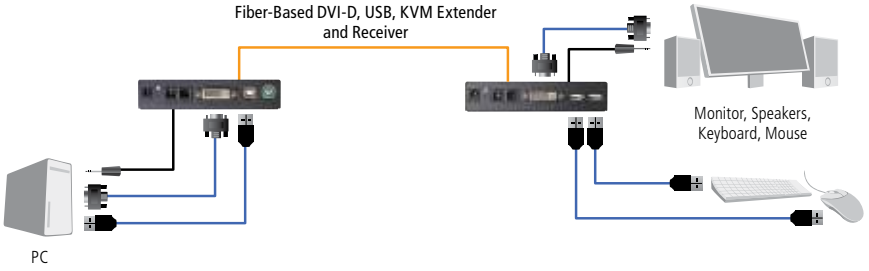
Non-networked CATx extenders use transmitters and receivers to extend converted signals over ordinary (non-networked) UTP cabling. They're very cost-effective and enable much longer distances than what's ordinarily possible with digital video cabling.

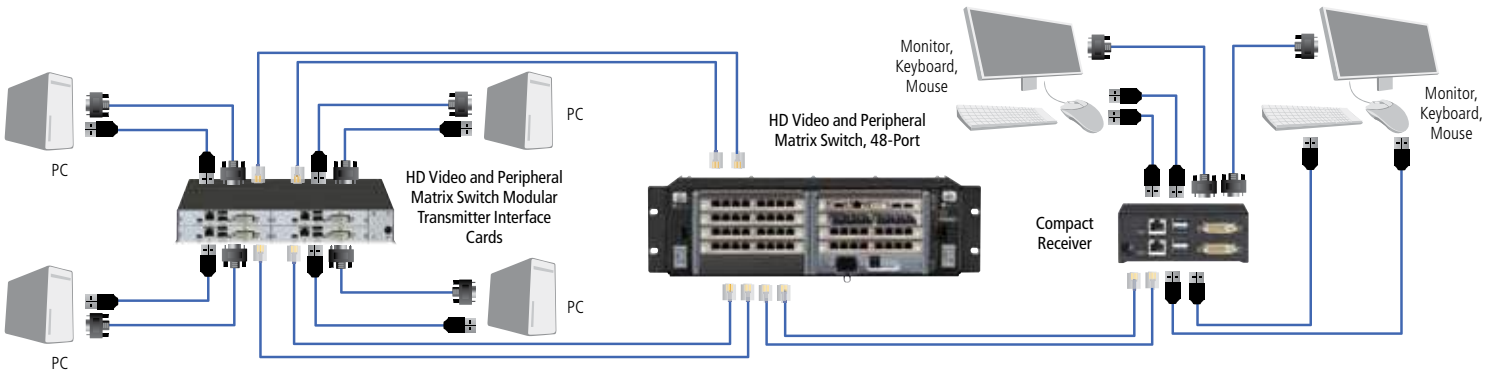


Point-to-point KVM IP extenders use transmitters and receivers to multicast DVI-D video and audio to a distant screen on your network. The transmitter and receiver install directly into your existing LAN infrastructure.



Fiber-based cabling extenders use transmitters and receivers to extend digital signals over secure, interference-free (non-networked) optical fiber. These extenders enable you to deliver video at much longer distances than copper.





Matrix peripheral switches (also called **crosspoint switches, or routers**) extend video, audio, and USB peripherals to any number of computers and CPUs on your network. You can use a system like this to distribute HD video and USB over copper or fiber, and all ports on the central chassis are input or output.

This kind of chassis-based modular system is flexible, scalable, and highly reliable. It provides instantaneous switching of HD video and peripherals. Ideal for broadcast, healthcare, government, and other applications where multiple users need to collaborate and view a variety of media.

USB Essentials

USB's main attraction is that it makes adding peripherals to your computer incredibly easy. It enables you to connect peripherals to the outside of the computer so you don't have to open your PC. A USB peripheral plugs right into the port and works. You don't even need to reboot your computer.

Virtually every operating system (OS) on the market today is USB enabled. USB technologies come in a variety of versions and speeds. Logos were created for each of the product specifications, from standard USB 1.1 to SuperSpeed USB 3.0, the latest technology. The most common version in use today is USB 2.0.

USB Extension

Although USB is a versatile serial interface, it's subject to an inherent distance limitation of five meters (16.4 ft.). USB extenders enable USB peripherals to be placed wherever users need them, up to 2 kilometers (1.2 mi.) from a host computer. With a USB extender, peripheral devices function as if they were within the five-meter limit specified by USB Implementors' Forum (USB-IF), which prepares the specifications for USB technology.

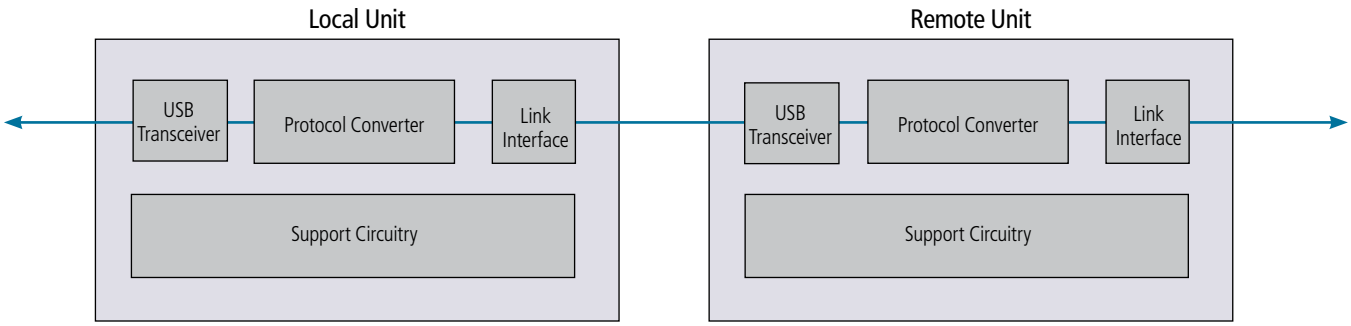
USB extenders preserve standard USB functionality and timing restrictions while accommodating the increased cable delay incurred in extended-range transmissions.

USB extenders are composed of two units connected by a transmission line. These units are referred to as the local extender and remote extender. The local unit is connected to a downstream-facing port of a USB host controller or hub; the remote unit is connected to the upstream-facing port of a USB hub or device. Once operational, the entire USB extender system operates like a single standard USB hub.

As a standard USB hub, the USB extender system is compatible with all operating systems that support USB hubs and requires no additional software to be loaded.

Because the system appears to be as a conventional hub (albeit a very long one) it can be connected to other hubs to the full depth permitted by USB. The system can be used as the first, last, or any intermediate hub in a chain. Multiple systems can also be used in parallel within a single domain—a common situation when opposite ends of a building need to be reached from a central computer room or telecom closet.

The only restriction placed on the configuration is that multiple USB extenders cannot be connected in series. Most USB extenders use CAT5 cable; if you require extra distance, you might need to consider a different cable type, such as fiber.



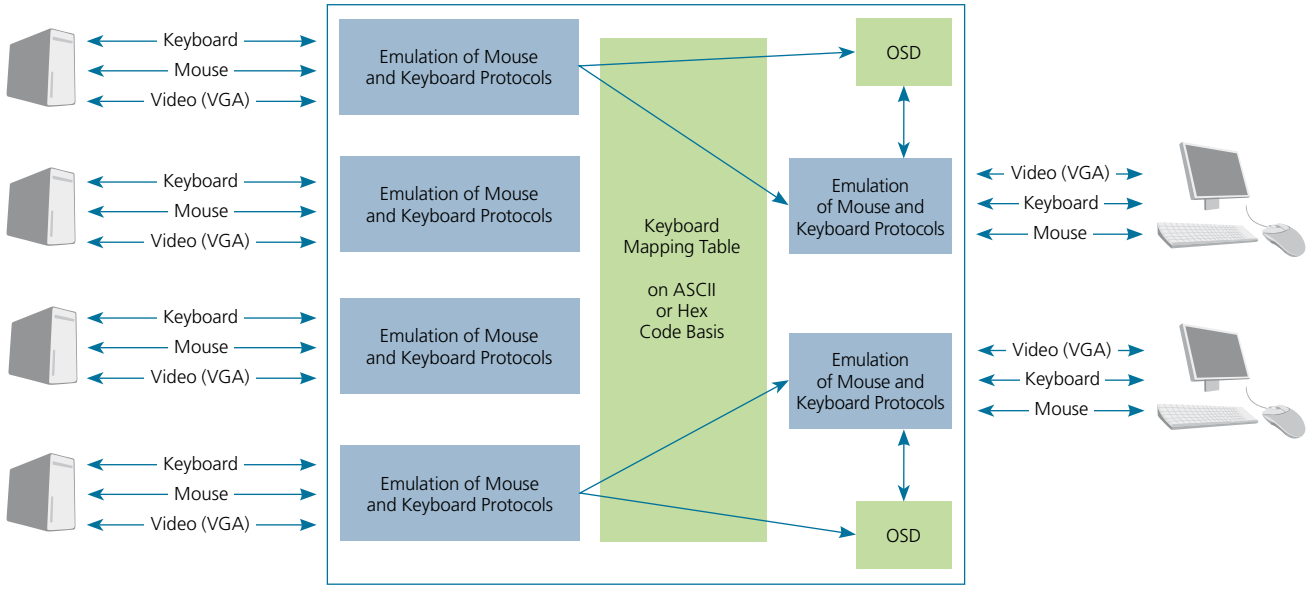
Video and Peripheral Extension

One of the most common types of video and peripheral extension is keyboard, video, and mouse (KVM) technology extension. These types of switches and extenders connect users via human interface devices (HIDs), like keyboards, monitors, touchsceens, and mice) to target devices—servers, workstations, computers—without the need for drivers to be installed on the target devices. This type of video and peripheral extension is a middleware solution—neither wholly hardware nor software—to extend or switch primarily KVM signals. Most switches or extenders will also support audio, RS-232, and USB signals. The goal of video and peripheral extension technology is to share resources and improve operability transparently.

In general, good extension solutions have a low total cost of ownership (TCO) because they last seven to ten years. This means they survive at least two generations of targets and peripheral devices, which usually are updated much quicker. Good video and peripheral extension devices shouldn't need to be replaced that quickly. They should demonstrate future compatibility through connections, cascadability, and scalability.

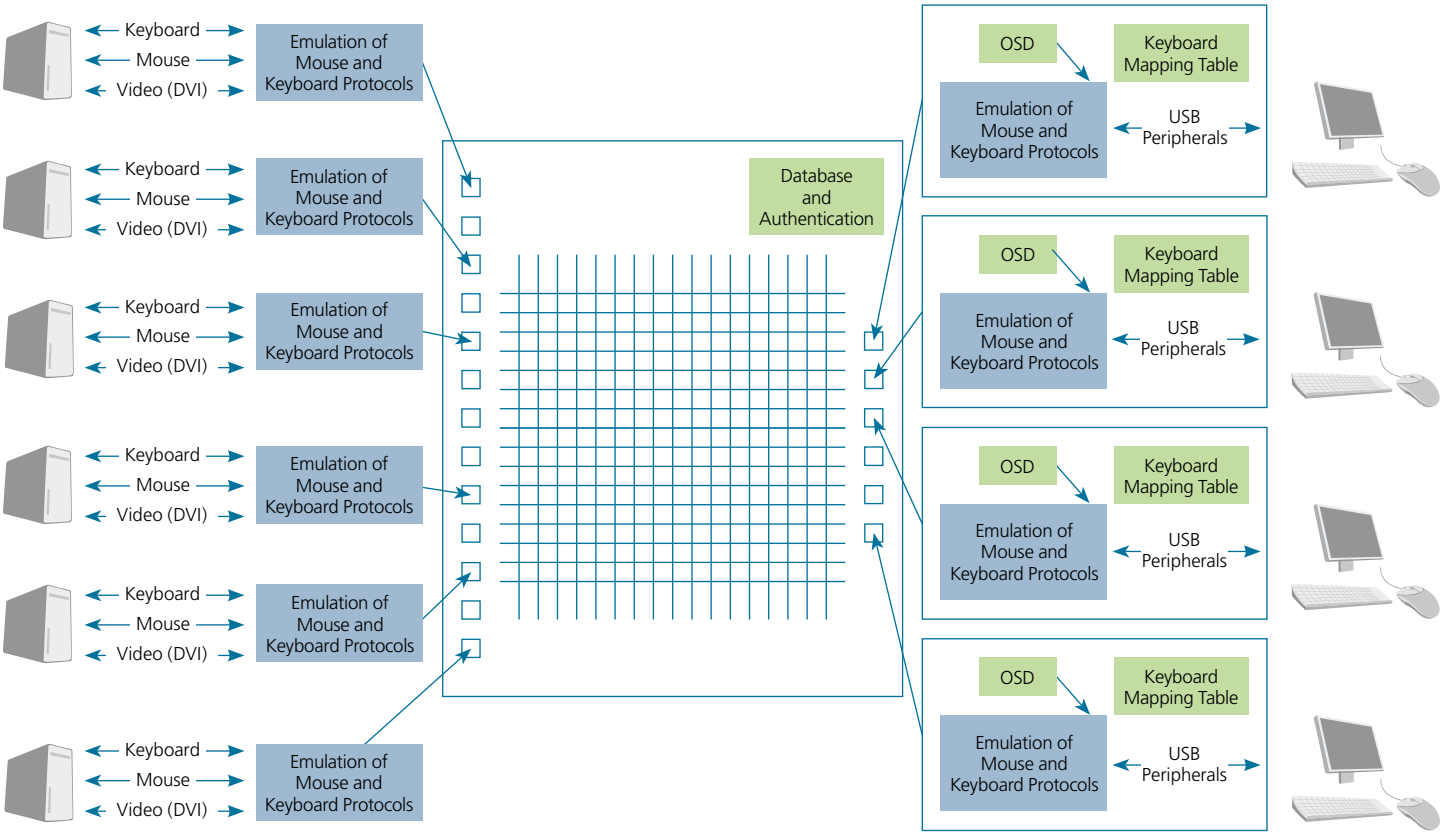
Video and peripheral extension solutions should also offer a quick return on investment (ROI). By improving operability, ergonomics, and work time savings, this type of extension leads to a more efficient use of human resources. In addition, video and peripheral extension is a green IT solution, leading to energy and cost savings.

Functional Diagram—Multiple User Video and Peripheral Switch



Traditional desktop KVM setup.

…and how it is done in a proprietary Multiuser CATx/Fiber Matrix



Matrix (or crosspoint) switching of DVI signals and USB peripherals.

Matrix Switching and Video Extension: Choosing the Right Technology

The way you choose to configure your matrix switch or extension setup depends on your application. For video-heavy extension over short distances, you can choose an HDMI or a DVI repeater using native cabling, or an extender kit using proprietary uncompressed technology. For mid-range applications, HDBaseT or compressed extenders may be the best choice. These can be either IP-based or use proprietary standards. For runs exceeding 400 feet, the options will either be to use fiber optic extenders, convert the signal into IP and run it over the network, or use multiple repeaters along the cable.

In collaborative environments with video extension and peripheral switching, matrix switch technology is the wave of the future. Again, the options are proprietary CATx and fiber optic cabling infrastructure or taking it to your IP network. These flexible switches extend and switch HD video and peripherals in real-time and instantaneously. Combining matrix and video extension solutions, USB extenders, and KVM setups gives users an almost endless number of configurations for their applications, from broadcast and command and control rooms, to healthcare settings, manufacturing, education, and more.