ESPORTS WHITEPAPER

DISPLAY MANAGEMENT IN ESPORTS APPLICATIONS

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INTRODUCTION

While the term Esports is increasingly perceived as being misleading, the competitive nature of most online games of various categories and the production requirements at live Esports events are very similar to the challenge typical sports venue productions encounter.

For IHSE, a leader in Display Management technology and KVM (Keyboard Video Mouse) extension and switching solutions, the factors determining a flawless gamer experience, arena operation and professional AV production for streaming and broadcasting are particularly relevant. Any human user interface extension, signal switching, video format conversion and video wall adaption has to comply with the needs of competitive, professional players, the audience as well as venue operators. In the case of a live event when teams of online players compete, systems must enable the best possible workflow for the production crew and meet the expectations of the venue audience as well as the viewers of live or on demand streamed content via twitch.tv or youtube.com.

Each type of game, from Mario Kart or Fifa World Cup to First Person Shooter (FPS) games played in squads or in solo-mode with the aim to be the last person standing, has loyal fan communities globally. As of 2019, the major Asian markets include China, South Korea and Japan complemented by the North American and European markets. Most players in Asia are between 25 and 34 years of age (Source: Nielsen Report cited in THE ESPORTS OBSERVER, 13 June 2019), while the average gamer age in North America and Europe is similar, but a little oder on average.

This presents a key opportunity for traditional television production and broadcast companies to connect with a younger audience. This age group is increasingly disengaging from traditional, linear TV. The major Esports competitions attract large audiences similar to major sports events such as basketball championship games, tennis tournaments or car racing events like the Daytona 500 or the 24 hours of Le Mans.

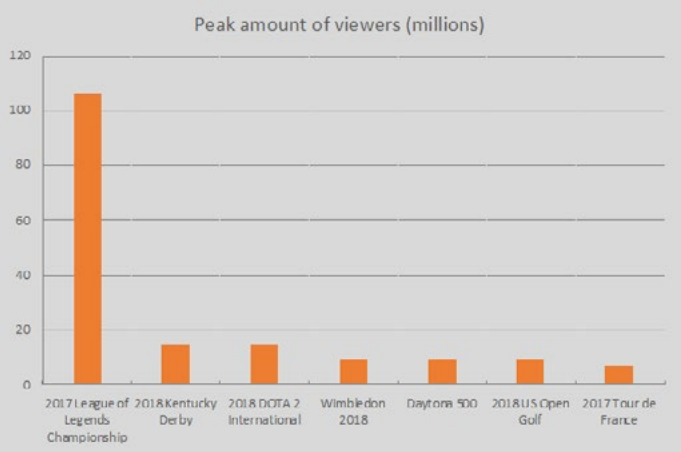

Figure 1: Peak viewership of Esports games competes effectively with „analog sports" broadcasting.

Source: Esport Charts, Sports Media Watch, Wimbledon, cyclist.co.uk, Washington Post 27. August 2018.

According to Statista (Newzoo), the worldwide Esports audience is expected to grow from 395 million in 2018 to 644 million in 2022. While viewers in most geographies prefer streaming services, in South Korea however, the majority of viewers uses traditional TV sets to follow the large competitions. In other parts of Asia, the use of smartphone screens to follow events is higher than in North America or Europe.

MMORPGS LIVE COMPETITIVE EVENTS

A modern online gaming event has all the attributes of a large music or sports event with extensive multimedia displays for the audience. This demands an ultra-high bandwidth wireless infrastructure to enable in-seat personalization to complement the video walls showing game action and a signal distribution and management environment with very high bandwidth and extremely low latency.

A distinct difference between an online game event and a physical event (often termed "analog") is the physical nature of the stage or playing field. The virtual nature of the Esports playground discounts cameras as a means to provide special views. However, these views can be created from gaming server data offering almost infinite possibilities to create viewing angles.

THE ONLINE GAMING ARENA AND THE PLAYER STATION

In many cases, traditional in-door sports arenas are used to host live online gaming events. The permanently installed large display facilities in these arenas often prove insufficient for the spectators at the venue and have to be complemented. Incremental AV infrastructure and signal management is needed. In response to these challenges, Philadelphia Fusion announced plans in early 2019 for a purpose built Esports arena seating 3,500 spectators. It is expected to see two approaches for live Esports event AV production: a flexible video/broadcast production environment easily installed in multi-purpose venues and, on the other hand, dedicated, purpose-built arenas.

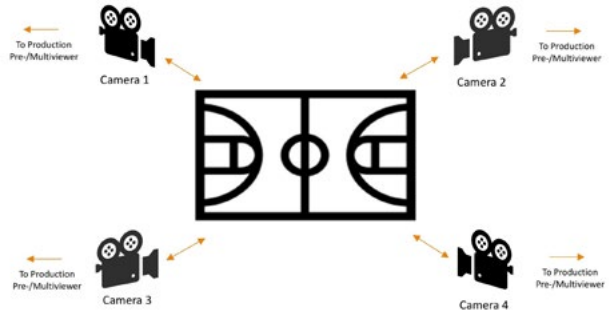

Figure 2: Analog sports field and camera coverage.

In analog sports, the fields or tracks are physical and are covered with traditional cameras and populated with human players. In Esports, the playing field is virtual and as such only visible to the players. In online games, a central server establishes the playing environment and provides each player a dedicated view depending on position and orientation. This functionality is used to introduce virtual cameras offering additional in-game views.

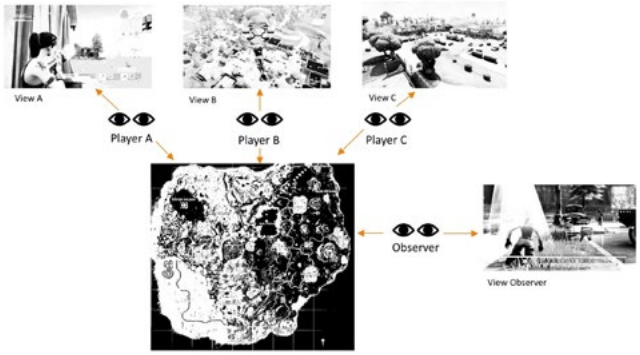

Figure 3: Esports field/world and player/Observer views as „camera sources“

These additional video sources are available to the Observer, typically an expert for a particular game and acting as a pre-selector for interesting gaming action based on overall map information and player status made available to her or him within the game. Observers with a good understanding of where the most interesting action takes place are in high demand.

Currently, most venues are for shared usage utilizing existing premises such as:

- Sports arenas
- Conference/Exhibition Centers
- Large hotel facilities
- Casinos

Dedicated, purpose-built Esports venues are still rare and mostly in the planning stage. It is anticipated that the number of purpose-built arenas will significantly increase over the next five years until 2025.

THE PROFESSIONAL PLAYER

Professional players, like in all sports, are rare talents with a gift and perseverance to achieve extraordinary results. They need to practice regularly for several hours per day and must be at ease performing in a public event with all eyes on them. A webcam right in their face will record emotions and reactions when stress-levels are unbearably high. The recent influx of prize money has attracted many good players and raised the standards in professional Esports considerably.

Player preferences and physical parameters

In the professional competitive domain, most players prefer a higher screen framerate over resolution. The higher framerates allow the fastest responses to game action. The entire gaming experience is perceived as more fluid or natural. As a result, many arena player stations only support HD resolution (1920 x 1080 pixels) to allow frame rates as high as 240 frames per second with the most powerful graphics cards. The screen resolution will also impact mouse sensitivity settings and requires adjustments in the game´s video settings.

SELECTED COMPUTER PERIPHERALS SETTINGS TO CONSIDER				
Mouse	**Monitor**	**Mousepad**	**Keyboard**	**Headset**
■ DPI / CPI sensor capabilities ■ Spatial Mouse Sensitivity X, Y ■ Mouse Targeting Sensitivity ■ Mouse Scope Sensitivity	■ HZ/Frames per second ■ GPU speed & v-sync settings/ capabilities ■ Screen Resolution ■ (In-Game) Video Settings	■ Type ■ Material ■ Size	■ Brand ■ Model	■ Brand ■ Model

Figure 4: Typical parameters adjusted for optimal gaming experience.

To enable optimal adjustment of the player to the game, the player focuses mostly on 6 domains to optimize the human – game interaction. 5 of them are listed in Figure 4 and the sixth is of course the PC itself. As in any optimization process, too little of anything yields as poor results as too much does. Finding the perfect balance is very important for top performance.

The simplified player desk/gamer station

Figure 5 depicts a simplified overview of the arena player desk equipment. The focus is on the electronic equipment, the player needs to perform. PC hardware development is very rapid and this paper discusses only generic features and capabilities.

Each player needs a processor/PC to run his or her instance of the game and a connection to game server infrastructure. A major element within the PC is the graphics card and its adaptation to the game.

The average reaction times of professional players usually put them at the top end of the scale of measured human reaction times across a representative sample of average humans and even compared to other players. A gamer station should ensure, that all graphics and game processing is significantly faster than the reaction time of the player. Monitor, mouse, keyboard and headset complete the basic technical setup.

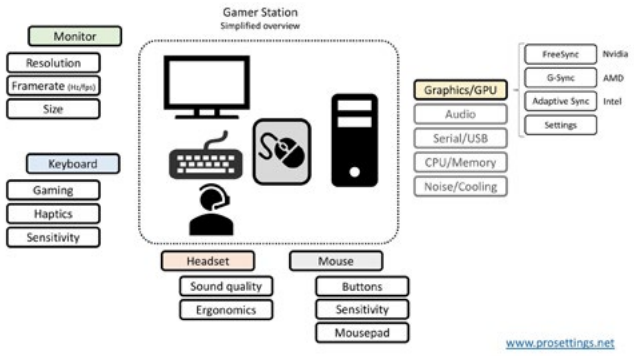

Figure 5: Simplified overview of the gamer/player station

The PC

It contains all elements required to process the software, physically hosts the Graphics Processing Unit (GPU), ethernet card and the USB/highspeed serial interfaces. For the PC itself, these components require attention to ensure compatibility and seamless fast operation:

- CPU with the following parameters to evaluate:
  - Match clock frequency, number of cores enabling parallel processing and number of threads with what the (gaming) software actually supports.
- CPU cooling system (high end gaming PCs already support water/liquid cooling), cooling is particularly important once CPUs are operated above their specified clock speed.
- Motherboard, chipsets:
  - Number and type of extension slots, available bus systems.
  - Type/speed of RAM supported and number of slots available.
  - Number of USB ports, number of USB hubs to ensure fastest possible transmission.
  - Speed and type network connection. Today, optical connections are becoming more common.
- Graphics card (GPU)
  - Clock frequency.
  - Graphics memory size and speed.
  - Power consumption.
  - Bus width. Bus refers to parallel signaling lanes, each carrying part of the data. The wider the bus, the more lanes and subsequently a higher data throughput.
  - Communication capabilities with displays via standardized interfaces.
- RAM or volatile memory.
  - Size, clocking speed of storage in Gigabytes.
  - Type and speed of data bus.
- Mass storage, non-volatile
  - Storage size in Gigabyte.
  - Solid State Disk, SSD, preferred for higher read/write speed.
  - Type/speed of physical interfaces, for example SATA/eSATA.
  - Read/write speed. Achievable speed of Input/Output (I/O) operations (IOPS).
    - Sequential I/O: larger blocks of information are written or read in a contiguous manner.
    - Random I/O: small quantities of data are stored or read at random intervals.
    - Both depend on the controller speed and the level of disk fragmentation
- Power Supply Unit (PSU)
  - Output power in Watts. The more components in the PC, the higher the electric power consumption.
  - Efficiency: is typically derived from the amount of output power in relation to the required overall input power. Low efficiencies indicate power supplies, which dissipate more heat, which again would increase the cooling requirements.

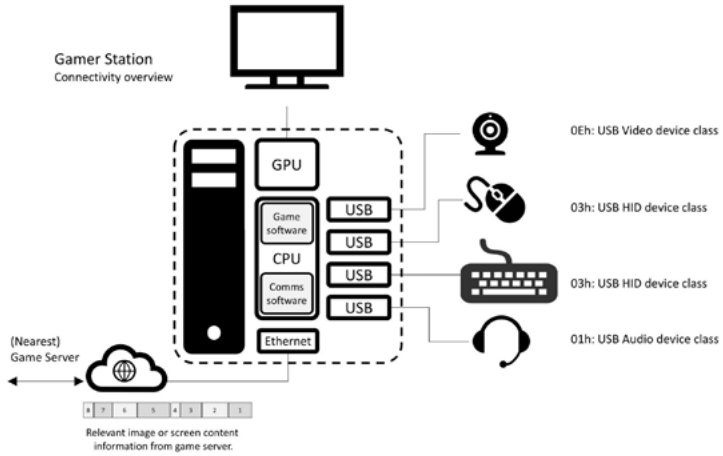

Figure 6: Simplified Player/Gamer Station peripherals connectivity

Connecting the peripherals

The peripherals connected to the player station or PC are the mouse, keyboard and headset via USB. In the professional arena setting, a webcam is added. The display is connected to the graphics card output. It is either HDMI for frame refresh rates currently as high as 120 Hz or DisplayPort for up to 240 Hz. The connection to the game server is handled by the ethernet port.

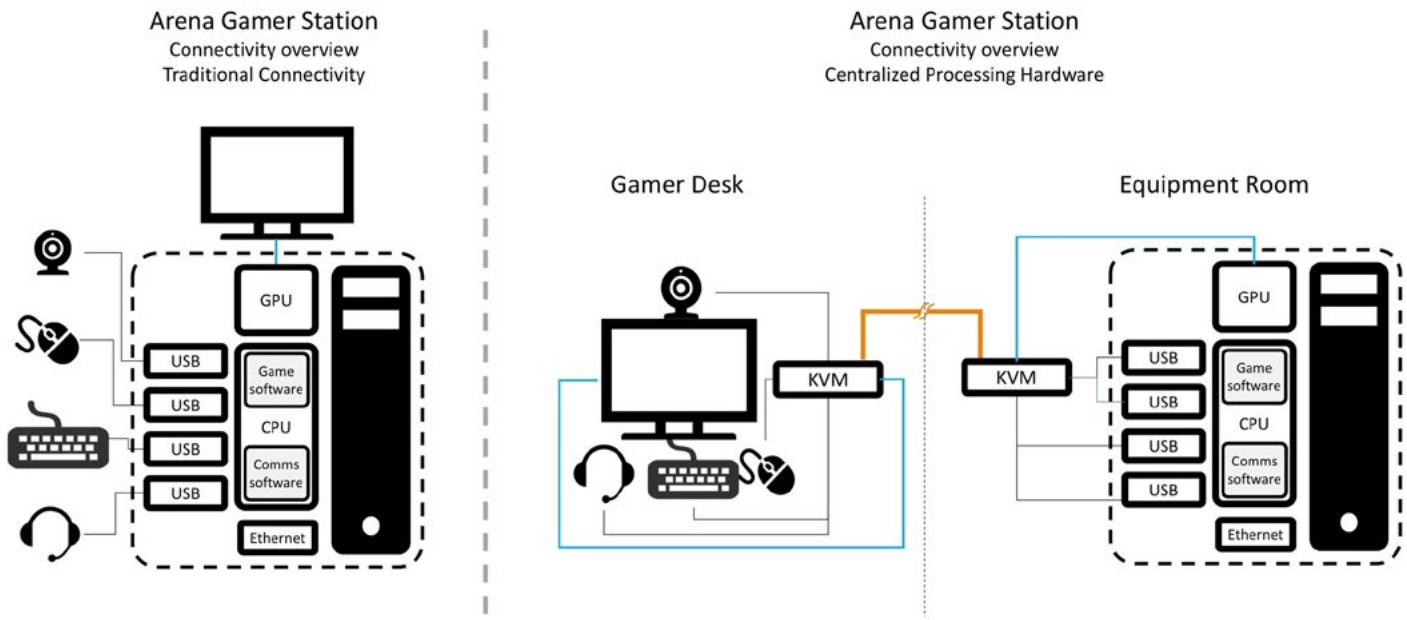

Figure 7: Arena gamer station, comparison between PC on site or back-racked via KVM extension.

Figure 7 compares two basic setups. On the left, the gamer PC is located at the player desk. On the right, the PC is moved to an equipment room and the connection to the desk is achieved via a KVM extension system. At first sight, this is not intuitive. A KVM system introduces additional hardware and subsequently more potential points of failure and it increases the delay between mouse or keyboard actions and their respective display on the screen. While this may be relevant in a home gaming environment, in a professional gamer arena, this makes a lot of sense, since teams play on identical setups. Co-location and back-racking of all PCs and the use of a KVM matrix switch with ultra-low latency significantly increase the flexibility and redundancy-options for a venue operator. It also improves the administration of the processing hardware located in one place and introduces the option of cooling the equipment room ensuring a smoother operation and longer equipment life.

Graphics Port

The gamer´s PC graphics port is mostly either a HDMI or DisplayPort interface. Both standards compete for leadership and are constantly upgraded. The currently (mid 2019) standardized and commercially available versions favor DisplayPort for ultra-high-framerate and low signal latency applications. While it is expected that HDMI will support 240 Hz refresh rates, at the time of writing this paper, DisplayPort has a leadership position.

USB

USB, Universal Serial Bus, is an industry standard for connecting peripheral devices to computing units via defined cables and connectors. Currently, Versions 2.0 and 3.x are the most widely used implementations of the standard. For 2019, the release of the 4.0 specification is expected.

THE ARENA PRODUCTION WORKFLOW

Production Crew

The E-sports production crew is quite similar to the regular sports production crew. A key difference is the role of the Observer.

Observer

This role can be understood as being an expert commentator as well as a special cameraman and even having director capabilities at the same time. The Observer is an expert for the game being played. He or she follows the game with an inside view and is expected to anticipate the decisive moments of the game and provide spectacular views of gaming action. The Observer guides the in-game views (see Figure 3) and makes them available to the video and audio production crew in the control room. Dependent on the game, video production set ups can have up to 5 Observers creating special feeds into the control room to create the most compelling visual experience for the arena audience and viewers of the live feeds on twitch.tv or youtube.com.

Typically, the Observer has a game screen similar to players and often at least one additional monitor for preview purposes. As a result, the technical requirements for an Observer station are very similar to the gamer.

Director and video/audio production crew

The main roles in the production or control room are:

- Director/Producer
  - Decides eventually on the content going out on the live feed for the audience in the arena and for the internet networks such as twitch or youtube. The Director closely cooperates with the Observer.
- Previewer control
  - Pre-selects feeds for the Director. These can be player webcam feeds, video selected by the Observer, Caster commentary, real camera feeds capturing the excitement in the arena, etc.
- Mixing video and audio
  - Video and audio mixing consoles are mostly separate in professional production rooms.
- Automation and scheduling
  - Manages stored assets and coordinates external feeds. This ranges from advertising to handling stored expert comments from other sites.
- Graphics
  - The graphics operator provides additional graphical information added to the video signal helping the viewer to better understand the situation in the game.
    - Analysis/overlay graphics.
    - Informational graphics.
- Replay
  - Replay is expected to provide detailed super slow-motion of key moments in the game, much like in analog sports. These key moments are of course decisions in fights and battles, but often they relate to the superior coordination of top players moves unattainable for most more casual players. This is equivalent to a spectacular dunk in basketball or a daring overtake in car racing. Replay must consistently acquire video at the fastest possible rate to provide as much detail as possible in a slower framerate replay for the audience.
- Transmission feed production (Conversion and compression)
  - Provide the outgoing formats agreed with the networks receiving and transmitting the gaming action. This also affects the large screen video wall presentation in the arena itself.
- Chief engineer
  - Focuses on the availability of all technical production facilities, can remotely access systems for reconfiguration, troubleshooting or analysis.

“High frame rate Replay” – Super Slow Motion

In any Esports production, high frame rate replays are key for the success of the production. The Gamer Station delivers typically a 240 Hz frame rate. The adequate signal management calls for a high framerate KVM system delivering four de-multiplexed streams at ¼ of the original frame rate. Figure 8 provides a generic overview of such a system.

The primary task of the KVM system is to provide a reliable de-multiplexing of the original 240 frames per second signal used in the arena gamer station. A signal splitting function in the KVM system establishes the connection between the arena gamer station and the equipment room hosting the PC/server infrastructure and feeds at the same time a demultiplexer, which is splitting the 240 Hz stream into four streams at 60 Hz. Each stream does not contain

consecutive frames but every fourth frame. This allows the use of standard broadcast slow motion equipment to capture the raw footage for the replay.

The slow motion replay server accesses the storage for each stream of every fourth frame and loads them into a 60Hz output stream. The combined stream contains all original frames now played at 4 times the original duration providing a super slow motion of key gaming situations.

Caster/Commentator

While the Observer is mostly focused on finding and providing the images that matter most, commentary is supposed to provide context and background information about the game, players and teams and in some cases keep the audience engaged in between matches.

Arena audience

The arena audience mostly follows the game on large video wall screens and experiences the event live seeing the players on stage as well as the game action on the screens. In the future it is expected that in-seat personalization will allow the audience to select individual views. WiFi 5 and 6 installations are expected to drive a richer experience for the audience in the arena offering a much higher data throughput. For the arena operator, personalization offers the opportunity to sell premium incremental services.

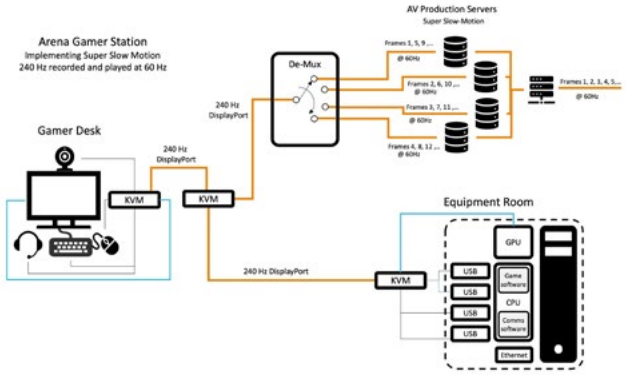

Figure 8: Signal-flow for super slow motion

Future experiences may even involve VR feeds for goggles connected at the audience seats allowing special views and movements of the audience within the game.

Internet/TV audience

The majority of online viewers globally use the PC as the primary device. In some regions, regular TV is gaining traction. Various forms of group or public viewing allow like-minded people to enjoy these events together.

Esports have successfully escaped a niche existence. Peak viewership effectively competes with traditional analog sports viewership and is bound to attract similar levels of advertising funding. The commercial expectations for the broadcasting of live Esports events are significant.

THE ROLE OF KVM (KEYBOARD VIDEO MOUSE) IN ESPORTS VENUES

Esports have come a long way in terms of professional production and providing a compelling audience experience as well as installing premier gamer stations meeting the high demands of the best players in every region. While in private online gaming setting a superior gaming PC can provide an advantage, the modern Esports arena is built to provide all teams and each player equal technical performance. While this may reduce the need to chase every millisecond of delay, the top gamers are expecting a fluid visual experience of the gamer station to allow them to show their best performance.

Operational efficiency and effectiveness during the Esports event

Esports production facilities have to design their technical layouts. Centralizing their processing units such as desktop PCs, computer workstations and servers allows them to capitalize on improved security, streamlined and faster maintenance efforts, expanded lifetime and performance of equipment in climatized rooms and reducing mean cost for cabling systems within the overall facility. Esports events taking place in traditional sports arenas add additional levels of complexity: portability, repeatability and speed of set up and tear down as well as skilled workforce scarcity of technical experts maintaining the system during the event.

One way to dramatically improve in all of the above-mentioned categories is to systematically separate the user interface consisting of keyboard, video display and mouse from the processing unit via a KVM-system (Keyboard Video Mouse).

One major concern with respect to KVM systems for the professional player is the added latency. To understand and estimate the impact of a KVM system, a round trip latency assessment is required. The aspects taken into account are mouse and USB lag respectively, game network and server infrastructure delays, player PC CPU and GPU processing time, display buffers and response time, human reaction time and KVM system delay.

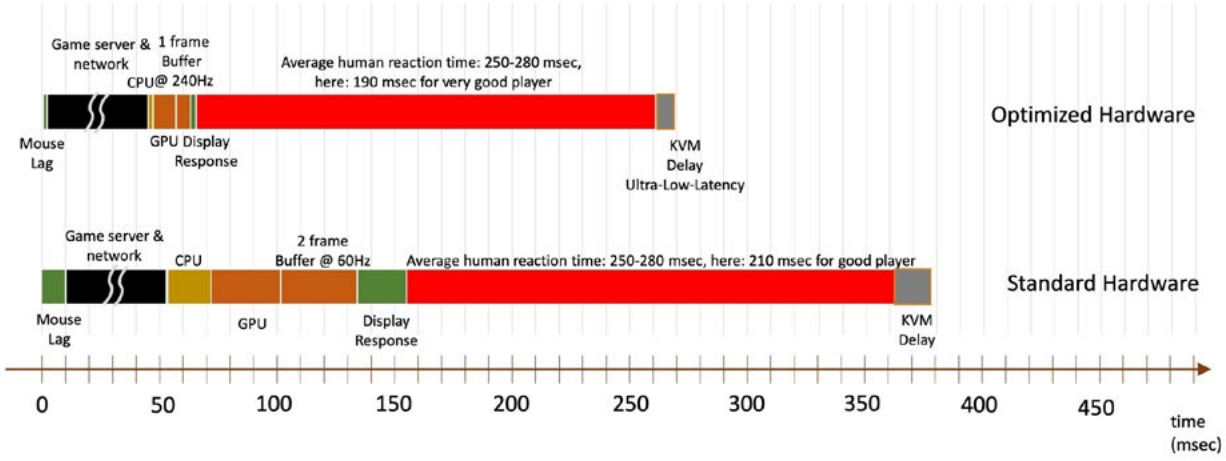

Figure 9: Latency/lag comparison, standard gamer hardware vs optimized

Two main conclusions can be derived from Figure 9:

1. Optimized hardware and player practice improve overall latency by over a quarter.
2. The main factors of delay are the connection to and processing of the game servers and especially the human reaction time.

Testing, measuring and exploring human reaction times has evolved as the discipline of mental chronometry. Simple tests ask participants to press a button as soon as they see a color change or hear the appearance of a tone for example. These simple reaction times suggest that auditory responses are faster (around 160 milliseconds) compared visual response times (around 200 milliseconds).

Human Benchmark has tested over 81 million people and concludes a median reaction time of 270 milliseconds. This however includes network delay and input lag of the computer, which according to Figure 8 can vary between 30 and 80 milliseconds. This would explain the higher values compared to laboratory tests indicating visual response times of around 200 milliseconds.

Gaming, however, is not just a reaction to a simple stimulus, but involves additional cognitive capabilities to recognize and differentiate. When test subjects are challenged with more complex interactions, response times increase significantly. For movement tracking tests, response times increase to 300 milli seconds. More complex cognitive tasks such as error corrections reach response times between 450 and 500 milliseconds. Esports games require pattern recognitions, friend / foe differentiation and other elements of situational awareness. Figure 8 assumes reaction times between 190 and 210 milli seconds, which, taking the complex nature of most games into account, is an assumption at the low end of achievable reaction times. Looking at the network, game server and human reaction time combined typically account for over 80% of the total delay for optimized hardware and about 65% in the case of standard hardware.

In both cases, additional delays caused by an ultra-low latency KVM system achieving below 5 milliseconds delay, account only for less than 2% of the overall lag experienced by the professional gamer in a realistic gaming situation. The operational improvements for arena operators will probably far outweigh the player´s objective to minimize every millisecond of lag.

Distributed processing components Esports arena

A typical Esports arena with distributed PCs, servers and video wall controllers is shown in Figure 10. While this is a conceptually straightforward approach, five significant aspects have to be taken into account.

- Any onsite maintenance requires covering a physically longer distance.
- Any failure of equipment requires “on-site” spares at every location in the arena. Additionally, exchanges disrupt schedules and prevent intelligent redundancy concepts.
- The setup is less flexible compared to a KVM extended and switched system, which can be easily reconfigured to set up extra practice desks, add additional Observers, Casters or large video wall screens.
- Cabling requires more different types of cables and as a result is more complex throughout the premise and subsequently more error prone.
- The gaming arena infrastructure set up requires significantly more time and higher skilled personnel.

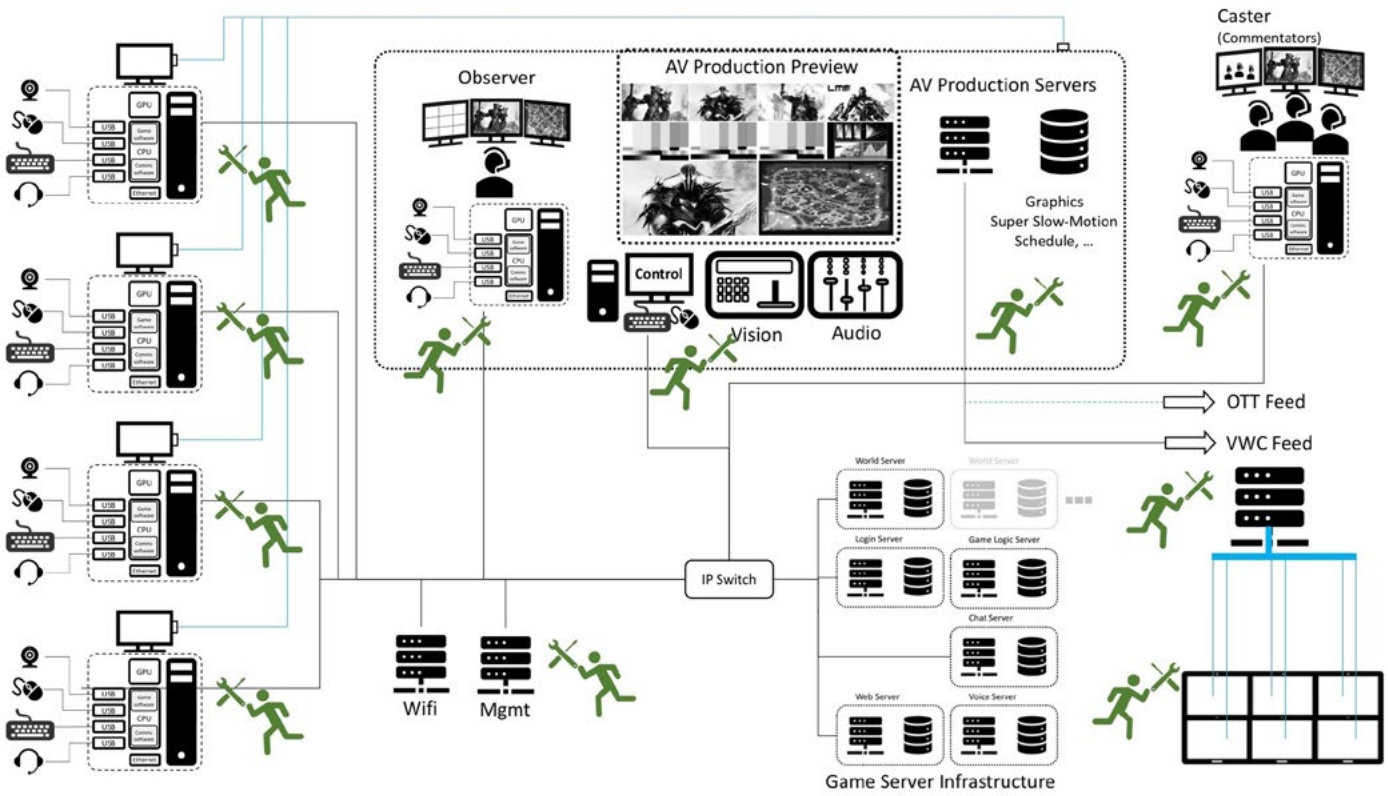

Figure 10: Current Esports venue architecture with distributed processing hardware.

Overall, this approach described in Figure 10 does work, but it does not lend to a streamlined operation helping event companies minimizing the cost to perform large scale Esports tournament series. This can be achieved by a streamlined Esports arena using a high port count, ultra-low latency KVM extension and switching infrastructure.

Streamlined Esports arena

The streamlined arena allows event operators to concentrate their processing units in one location. Whether rack-mounted fly-away kits are actually brought into a climatized zone or container or are located in a particular room, is up to the individual venue operator. However, having all processing equipment in one location radically simplifies maintenance and administration of the system, increases configuration flexibility and resource allocation and offers improved redundancy concepts to ensure a smooth, uninterrupted event.

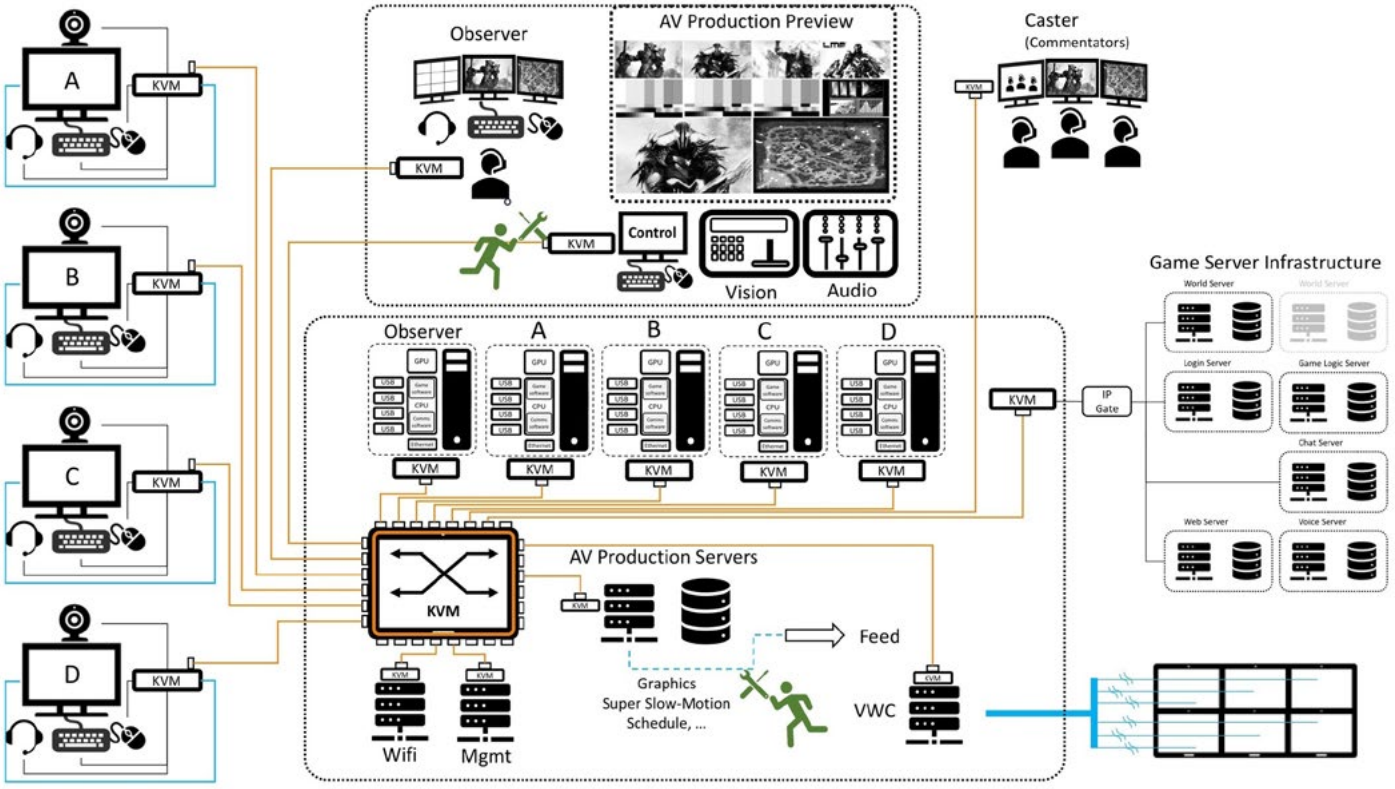

Figure 11: Streamlined and optimized arena processing infrastructure optimized for flexibility and service.

Figure 11 shows the optimized arena processing infrastructure relying on KVM switching and extension technology. The key aspects for selecting such a TRUE KVM system are:

- Ultra-low latency allowing the best ergonomic feel for the gamer and Observer.
- In-band signaling for system-wide control from one maintenance controller and out-of-band connectivity at the gamer station to connect all the necessary devices via their native interfaces.
- A flexible and modular switching architecture for easy and fast scalability.
- A secure by design KVM switch preventing illegal intrusion and manipulation of high stakes games.
- Hybrid connectivity to link to all relevant sources such as IP/ethernet, cloud, virtual machines, graphic ports, Serial Digital Interface (SDI) video, USB and even legacy serial interfaces.

IHSE has engineered high performance KVM systems for over 20 years and partners with players, production crews, venue operators and Audio/Visual system integrators in the Esports and broadcast industry to help find the best technical solution for today and in the future.

LIST OF ACRONYMS

Acronym	Explanation
Adaptive Sync	A generic name describing an optimization technique for video framerate performance while avoiding artefacts such as stutter and tearing.
Bit	Single binary unit, which can represent one of two states labeled as 0 or 1.
Byte	Unit of 8 binary digits (bits).
CPU	Computer Processing Unit, typically refers to the processing chip performing all necessary operating system and application program calculations. Often, it encompasses all necessary components to perform these calculations that can be found on the computers main board.
DPI	Dots per inch, defines a spatial resolution capability of a device, often a mouse.
FPS	First Person Shooter game.
fps	frames per second, rate of individual images per second displayed by the monitor.
Freesync	A special adaptive vertical synchronization system provided by nvidia optimizing video framerate performance while avoiding artefacts such as stutter and tearing.
G-Sync	A special adaptive vertical synchronization system provided by AMD optimizing video framerate performance while avoiding artefacts such as stutter and tearing.
GPU	Graphics Processing Unit, is typically a special board with significant electronic circuitry preparing the graphics information for the display connected. Often, these boards also manage audio.
Hz	Hertz, unit of measurement for repetitions/frequencies.
IPTV	Internet Protocol TeleVision, standard TV transmitted over an IP infrastructure. This is typically not a standard internet connection, but technically uses the same transmission protocol.
KVM	Keyboard Video Mouse: technology to separate the PC from the keyboard, video and mouse over a longer distance than the standard interfaces support.
LAN	Local area network.
LCD	Liquid Crystal Display, a computer display technology.
MMORPG	Massively Multiplayer Online Role Play Game
msec	millisecond, one thousandth of a second.
OTT	Over The Top, distribution of audio or video content over a standard internet connection to end users.
V-sync	Vertical synchronization. A timing marker used between GPU and display to identify when a new image (also called frame) has to be displayed.
Video Wall	A set of individual displays connected in a particular way to display a larger image and each display only shows part of the image.
Wifi	Abbreviation for a wireless LAN infrastructure.

HOW HIGH-PERFORMANCE KEYBOARD VIDEO MOUSE EXTENDER AND SWITCHING TECHNOLOGY ENABLES IMPROVED PRODUCTION WORKFLOWS AND PRISTINE VIDEO DISPLAY

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