Micro PCs for the Theatre

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DRAMA 577

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Table of Contents

1.   Introduction

1.1. Project Overview

Traditionally, projection and video in the theatre has been accomplished using large, expensive media server equipment. As smartphones have shown the power of embedded computing, what micro platforms can be used to achieve video effects? This report explores the use of low cost systems such as the Raspberry Pi, iPad and iPhone to create complex video effects on stage.

To provide context for this report, the University of Alberta's proposed production of Karel Capek's *R.U.R.* is used as an example to how technology could be used to "roboticize" or add physical computing elements to characters.

Emphasis is placed on the limited budgets of regional-sized theatres. This document is largely a survey of many different technologies, rather than a detailed analysis of any specific area. The goal is to allow savvy theatre technicians or visionary theatre artists to discover what is at their disposal.

1.2. Research Targets

Three distinct applications of the technology are examined, based on potential parameters for a production of *R.U.R.*.

- **Wearable video display :** A method for delivering video content to a screen worn by a performer, controlled remotely from a show computer.

- **Wearable performer data gathering :** A method of gathering movement, image, and button data from a performer for transmission back to a show computer for further processing.

- **Network media server :** A method of delivering video content from a show computer to a compact network media server/output device. (ie. for the video enhancement of mobile scenic elements)

1.3. Media Servers

To understand the functionality that Micro PCs might replicate, an understanding of what traditional media servers do is essential.

As of this writing, several commercial solutions are available for the playback and manipulation of live and recorded media (video, stills, animation, etc). Examples include Coolux Pandora, Dataton WATCHOUT, Green Hippo Hippotizer, and d3 Technologies. While their feature sets differ, their core purpose is the same: to playback and manipulate content for output to various destinations. Most of the products mentioned operate on dedicated server hardware for purchase from the manufacturer. At several thousands of dollars per unit, these solutions are not very accommodating to most regional theatres.

For this reason, software solutions that run on ordinary laptop and desktop computers are commonly used for playback, and will often match or exceed specifications of commercial solutions, but with reduced quality, reliability or usability. Examples include Millumin, Isadora, QLab, and VDMX.

This report will examine devices that are a less expensive and more portable as a complement to an existing playback system.

2. Raspberry Pi

2.1. Overview

Originally created to allow British schoolchildren learn how to program computers, the Raspberry Pi has since exploded onto the scene of makers, engineers, and electronic artists.

Offering much of the capabilities of an ordinary PC, the Raspberry Pi is not alone in the Micro PC market, or even the computer-on-board market. Its advantage over all others is its price of $35. A lower-end model is available for $25, which sacrifices one USB port, some RAM and the wired network port.

$35 makes it particularly attractive to small theatre companies that are looking to integrate video and interactive technology into their productions, and projects where equipping a large cast of performers with expensive smartphones or tablets would not be feasible.

Two models are currently available, with specifications as outlined in the table below.

Specification	Model A ($25)	Model B ($35)
Processor	ARM SoC 700MHz	ARM SoC
Outputs	HDMI w/Audio, Composite Video, 3.5mm Audio, (audio input via USB audio device),	HDMI w/Audio, Composite Video, 3.5mm Audio, (audio input via USB audio device),
Shared Video/System RAM	256MB	512MB
Networking	-	10/100
Connectivity	GPIO, Camera Port	GPIO, Camera Port
USB Ports	1	2
Power	5V Micro USB	5V Micro USB
Storage	SD Card Slot (32GB Max Class 10) - expandable via USB storage and/or network storage	SD Card Slot (32GB Max Class 10) - expandable via USB storage and/or network storage

2.2. Pi Accessories

In order to use the Raspberry Pi out of the box, a few accessories are required. Depending on its intended use, some accessories are optional. The bare minimum requirements are:

• **SD Card :** This serves as the main storage or "hard drive" for the Pi. Operating Systems can be loaded onto the SD card using disk images available for download from the Raspberry Pi website.

• **Power :** Supplied via Micro USB port (5V, approx. 700mA), most cell phone chargers from the past few years will work well to power the Pi. While some material suggests that AA batteries can be used to power it, this is not recommended without a regulator. You can also power the Pi from your computer provided you have a Micro USB cable. To make the Pi mobile, you can use consumer "battery boosters" that output USB at at least 700mA.

This is the minimum required for the computer to operate, and for large deployments, all that would be required provided all the programming is pre-prepared. If you are looking to use the Raspberry Pi by itself, you will probably need:

• **USB Mouse**

• **USB Keyboard**

• **Ethernet Network Connection :** (see Appendix A)

• **HDMI or Composite TV/Monitor :** (while HDMI to DVI adapters function as expected, you cannot use a VGA monitor with the Pi without obtaining an expensive active HDMI/DVI to VGA adapter – about $30)

Optionally you can also add:

• **USB WiFi or Bluetooth adapter :** A variety of inexpensive WiFi adapters are available online. Look for Realtek-based chipsets, which offer the best out-of-the box compatibility. Some users report requiring a a powered USB hub to use WiFi adequately; results may vary depending on the current available at your power source.

• **Case :** Many types of cases are available online to protect the Pi, or you can construct one using your own building materials

For detailed information about specifications and configurations, visit the online Raspberry Pi Documentation on the eLinux wiki http://elinux.org/RPi_Hub.

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2.3. OpenMAX Player

Equipped with a Broadcom System-on-a-Chip (SoaC), the main processor on the Raspberry Pi consists of a CPU and GPU with integrated RAM shared between the two. The chip is capable of playing full 1080p video at 30fps (television set-top boxes operate on similar chips from Broadcom); however this can only be done through specific programming operations.

You cannot, at this time, use VLC or other familiar video applications to play video at full speed on the Raspberry Pi, even though the software may load and open on the device. Video playback for these programs and the desktop environment as a whole has not been "accelerated" for the GPU on the Pi. Development continues to improve display performance for all programs.

All is not lost however, as there are software kits being developed that speak the OpenMAX language the GPU uses. Pi3D is a framework for Python that allows you to create high performance 3D graphics and environments on the Pi, which could be used by advanced creative coders in some theatrical productions.

Another command-line tool that has been long available for the Pi is *omxplayer*, which loads most QuickTime and other h.264-encoded videos from the SD card or the web. As *omxplayer* has a very limited interface, some tricks can be used to ensure it plays video on cue in a theatrical setting.

2.4. Cueing OpenMax Player

To cue up a video with *omxplayer*, the following technique can be used from the command line of any stock Raspberry Pi running Raspbian, the recommended operating system.

1. Make a "first-in, first out", or fifo device on the system. Anything "piped" into this virtual device will be passed back out as soon as something else "listens" to it. At the command line, type:

```
mkfifo /tmp/cmd
```

2. Pass the letter "p" for pause into this fifo device. Type the following into the command line:

```
echo -n p > /tmp/cmd &
```

3. At this point, we have loaded up the letter "p" into the pipe, so that when *omxplayer* is ready for playback, it will immediately pause the video. Start *omxplayer* by typing:

```
omxplayer -o hdmi yourvideo.mp4 < /tmp/cmd &
```

4. Some text may scroll by, indicating it has loaded the video file. Your screen may go blank as it clears it for video playback. To start playback we pass another "p" to toggle pause into play. Type:

```
echo -n p > /tmp/cmd &
```

… and video playback commences!

This process can be automated with a script that could respond to messages from a show playback computer running QLab or Isadora, for example.

To control multiple Pis at once, use the *cssh* utility, which allows you to connect to multiple computer command lines at once, and type the identical commands into each. Video sync of multiple Pis can be achieved using this method.

2.5. Case Study: Video Wall

With its low price point, the Pi is ideal in applications where it can replace a large number of computers. Video walls consisting of an array of televisions or displays are typically controlled from a group of media servers, or by costly video switching equipment.

Identifying a possible application of the Pi, engineers Alex Goodyear and Collin Hogben at the Culham Centre for Fusion Energy (CCFE) wrote software to unify multiple Pis into a single video wall. Each screen is powered by one Pi, with an extra Pi to control the entire network. While detailed information is not yet available, an email response indicates they are working to package the software for both commercial and non-commercial use.

With the commodity costs of HDTVs and monitors, this makes a medium-sized video wall within reach for regional-sized theatres. An 8' x 10' video wall could easily be built for less than $10,000CAN, with all materials reusable for other projects, resale, or rearrangement for a new production. See the table below for a breakdown of materials for a potential Raspberry Pi-based Video wall.

Item	QTY	Price	Subtotal
40" HDTV	9	$600	$5400
Raspberry Pi Model B	10	$35	$350
TV Mounting Hardware	9	$40	$360
Pi Cases	10	$10	$100
HDMI Cables	10	$5	$50
SD Cards	10	$8	$80
16-Port Network Switch	1	$50	$50
Metal/Wood Support Structure	1	$500	$500
Software	1	$200	$200
Total			**$7090**

2.6. Case Study: Wearable Computing

Towards the goal of creating **wearable display of video,** the Raspberry Pi is an affordable way of outfitting a large cast with video playback devices. Using remote cueing described in *Section 2.4,* it becomes quite realistic to remotely control a large number of wireless devices being worn by performers. Commodity 7"-9" portable DVD players equipped with built-in batteries and video input can be attached to the Pi using composite video. For a higher resolution work, video screens designed for video monitoring from HD camcorders such as those from Lilliput® can be connected via HDMI. These models will often be powered from standard-sized video camera batteries, which are more easily charged and managed than the integrated ones of portable DVD players.

A compact Lilliput display.

To power the Pi and any accessories, a rechargeable "cell phone recharger" or similar device with USB output works well. I have experimented with the Yoobao 13000mAh ($75), which would easily power the Pi for about 12 hours. Dual USB ports make it simple to power other 5V devices to be worn by the performer.

Wireless adapters are available for under $10, as described in *Section 2.2.* For better wireless performance, USB dongles with an option for an external antenna is ideal. Antennae mounted close to the human body can

The Yoobao high-capacity USB battery.
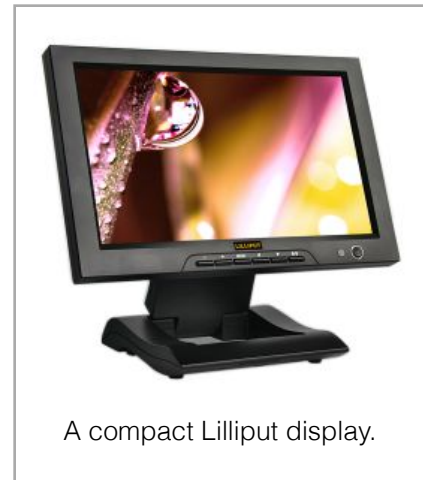
reduce WiFi power significantly. For more information about networking suggestions, see *Appendix A - Network Considerations*.

While the Raspberry Pi itself is inexpensive, the system of components required to deliver a wearable video system for performer can become quite costly and unwieldily. A tablet computer may be more appropriate for strictly video purposes, as it offers integration that cannot be achieved on a Do-It-Yourself (DIY) basis.

Where the Pi excels compared to a tablet device is its ability to integrate with other electronic components. Equipped with a General Purpose Input Output (GPIO) connection, the Pi can control and sense electronic circuits. Many kits are available from creative electronic websites such as Adafruit.com, that expand the "physical computing" possibilities of the Raspberry Pi.

I have experimented with one such kit. The RGB LCD Shield Kit w/ 16x2 Character Display (ID #714, $24.95) that adds a two-line 16 character multicolour backlit screen to the front of the device, along with four navigation and select buttons. In configurations where the Pi is being worn by performers, this would easily allow IP address, battery measurements and WiFi signal strength to be displayed for on-stage diagnostics, even without a display attached. Simple-to-use Python frameworks are provided to control the display. I used the "aufder / RaspberryPiLcdMenu" github project as the basis for a video playlist selection menu I wrote.

The 16x2 shield kit from Adafruit.com

Alternatively, the Pi can serve as the central computing behind additional electronic control boards, such as the Arduino. The Arduino electronics prototyping system offers the ability to program and control lights and motors, while responding to input such as buttons or dials. A special version of the Arduino board built especially for use in clothing called the Lillypad can perform functions with electronics sewn into costume with special conductive thread. (See Teri Hovstead's *Electronic Textiles* - DRAMA 577 2011 for more information). Combining the simplicity of Arduino with the power of Raspberry Pi would allow more sophisticated on-the-fly programming of eTextiles, and allow larger systems to be linked together to a single Raspberry Pi on the performer. Possibilities become more sophisticated with the power of a full PC in a small form-factor.

Finally, the Raspberry Pi is equipped with a port for a camera module that is currently in pre-production at the Raspberry Pi foundation. While existing technology allows for live streaming of camera input on smartphones to media server systems, the quantities in which this

The Lillypad Arduino-based eTextile chip.

can be operated is limited by budget constraints for purchasing smartphones. (See 3.4 Wireless Camera Input)

Conversely, an array of a dozen Raspberry Pi with cameras could provide a completely different visual experience. You could even conceivably stream video in 3D using software on the remote PC.

2.7. Pi Conclusions

Pros: price, flexibility, integration potential

cons: knowledge required, custom builds

Ideal use case : experimenting and prototyping, low-cost functions, large scale installations such as video walls

3.   Tablet Computers

3.1. Overview

Tablet computers are being widely used for entertainment at home and productivity in the workplace; however for our purposes they are essentially well-equipped portable displays. In this section the Apple iPad will be explored as a video device on-stage. Available in 7.9" and 9.7" sizes and starting at $329CAN, these represent a good value for the integration of video screen, computational power and battery life. It also exceeds any DIY solution in terms of convenience and physical size.

The iPad is the ideal wearable display. Easily sewn into the pocket of a costume or scenic element, the design makes it simple to deploy, handle, and maintain.

In terms of video playback and control, there are a variety of options for live playback, as well as sensor data gathering and video streaming.

Many of the options discussed could also be deployed using iPhone or iPod Touch, which may be more accessible to a particular theatre company (the former being relatively ubiquitous among performers, and the latter being more affordable than both the iPad and the iPhone). The iPad is used as a case study, as it represents the largest screen real estate currently available, improving visibility in large performance spaces.

3.2. Portable Media Server

As discussed in *Section 1.3 Media Servers,* the core function of a media server is to playback and manipulate media. Hexler TouchViZ achieves this on the iPad, written especially for visual performance artists. It is equipped with a two layer playback engine, 125 clip video bin, 17 useful effects with parameters (applicable to a single layer or the master layer), even master colour and level control of the output image. What makes it particularly useful for theatrical use is that the entire interface can be manipulated remotely using OSC or MIDI.

Courtesy Hexler.net

These controls are easily inter-faceable with existing software such as Isadora or oscseq. Better yet, an unlimited number of iPads running TouchViZ can be controlled on-stage wirelessly, all on their own graphics power.

One limitation of the product is that video does not go completely full screen on the iPad display itself. The software is designed to output to a projector or video screen using the Apple Dock Connector to HDMI adapter, Dock Connector to VGA adapter, or via AirPlay. Thus, when full screen mode is enabled, a horizontal bar still appears along the top of the screen to exit full screen mode. This could be easily masked with gaffe tape or similar to avoid being visible onstage. A feature request has been submitted to the developer to see if a true full screen mode could be added in future releases of TouchViZ.

Video content can be copied to TouchViZ from iTunes, or imported from the Camera Roll. In addition, many iPads can be configured with the same content at once using Apple Configurator (see *Section 3.7 Mass Deployment*).

For iPad 2 or better–$9.99.

3.3. Wireless Additional Monitor

An alternative way of outputting video to the iPad from a remote computer is using the AirDisplay software. On the show computer, a special driver is installed to simulate the connection of a second display on the computer. Video passed to this monitor is then transmitted to the iPad app

running on the device, and displayed in realtime.

The advantage of this technique is that it can be used with almost any existing video software on Mac or PC. Isadora, Millumin, and QLab can all output to it as if it were any other display device connected to the computer. This allows it to integrate easily into existing workflows.

Unfortunately frame rate is limited by the quality of the wireless connection between the control computer and the device. This means video

Courtesy CNET / Avatron Software

playback can get choppy or even unusable, although crossfading between still images can be achieved quite successfully even on mediocre connections.

Another limitation is that only one iOS device can be linked to a computer at once. If the goal were to operate a full suite of iPads on stage, an equal number of control computers running the AirDisplay software (and playback system!) would be required. As an alternative to using AirDisplay in this scenario, multiple physical monitors could be connected to the control computer, and iPads could connect using remote desktop applications (VNC) and display only their delegated monitor.

Despite its limitations, AirDisplay is a simple and quick way to get started with remote video.

For Mac, PC, iOS, Android – $9.99-$19.99 or Free with Ads.

3.4. Wireless Camera Input

Obtaining reliable, high resolution live video from on stage is always a challenge. Webcams are awkward to integrate, and do not always offer ideal quality. Cabling the device back to the control computer is also a challenge.

AirBeam solves many of these problems by transmitting a live feed of the front or rear camera of any iOS device over the network. Launching the app immediately starts broadcasting of a built-in web server to the network, for viewing or control of the device.

A companion app for the Mac allows low-latency viewing of any AirBeam camera on the network, as well as Syphon streaming out of the application. This allows any Syphon-enabled programs such as Isadora or Quartz Composer to stream the video in real time into their application for

further processing or output to stage. AirBeam uses two different codecs: h.264 compression on the Web Interface which offers superior compatibility, and motion JPEG which offers incredibly low-latency encoding and transmission.

With a variety of resolution, quality, and frame rate parameters controllable via the Web Interface, I have created a patch for Isadora/ Quartz Composer that transmits appropriate values to the device from the cueing environment. This allows front/back camera control, torch on/off and more to be preset in a particular scene of a production. Visit http:// jole.ca/posts/airbeam-controller-for-isadora-core-quartz-composer/ for more information and to download the patch.

AirBeam being used in ShowStages *production of* The Haunted Reel *(2012).*

For iOS and Mac – $3.99.

3.5. Gyro and Accelerometer Data

Most late-model iOS devices are equipped with accelerometer and gyro sensors, which provide detailed movement data about the device in every axis. GyrOSC gathers all of this sensor data and transmits it over the network via OSC.

In situations where the device is attached to a performer, live movement data of the artist can be transmitted back to the video control computer for further processing. For example, the movement of a dancer performing a pirouette could be mimicked in the visual shape of projected media. As all data is transmitted over a WiFi network, multiple performers could inform the shape, color, or any other parameter of the video performance.

For iOS devices equipped with adequate sensors – $0.99

3.6. Mass Device Deployment

In preparing large numbers of iPads and other iOS devices for use by several performers for example, tools created for Enterprise IT can also be used to save time on stage.

The Apple Configurator tool allows system profiles, applications, documents, and user settings to be copied and repeated to several iOS devices at once.

For example, suppose you have a cast of five performers, three of whom wear iPod Touches in their costumes running GyrOSC, and two wearing iPads that display video clips with TouchViZ throughout the show. Manually configuring each device for correct WiFi settings, applications, and assigning the correct video content to each would be a labor-intensive task.

Apple Configurator can prepare these settings in advance on any Mac, and then upload all information to the device simply by connecting it to the computer via USB. This also ensures that the configuration of the device is consistent for every performance, as settings can be reapplied regularly.

Apple Configurator is available on the Mac App Store, and requires the latest build of OS X Mountain Lion – Free.

4. Home Media Boxes

4.1. Overview

As HD video playback becomes an essential part of the home entertainment industry, home media boxes have become inexpensive ways of playing and managing video. Apple TV offers a variety of media playback options, but of particular relevance is its AirPlay capability.

Apple TV costs $109 CAD, is extremely power-efficient, and operates on a modified version of iOS. It can also be configured using the Apple Configurator tool (see *3.6 Mass Device Deployment*). Third-party software modifications are also available for the device, but are not explored here.

4.2. AirPlay

AirPlay technology encompasses many different situations where Apple devices can stream multimedia from one device to another. Audio can be streamed from iPod to Apple TV, or to iTunes on a Mac, for example.

For theatre, Apple TV is particularly useful for transmitting video via network over long distances. TouchViZ (Section 3.2) can output cleanly to Apple TV over AirPlay, for example. Most late-model Macs Running OS 10 Mountain lion and above can mirror one display to Apple TV.

Unfortunately the Apple TV is still designed to be a media centre, and is limited by these device parameters. For example, mirroring and not desktop extension is the only supported method of transmitting video at this time. If only stills are required for playback during a show, the Photos app could be used from any iOS device, however, one runs the risk of dropping into the Apple TV main menu in front of an audience if something were to go wrong.

4.3. AirParrot

One software modifications for the Mac allows AirPlay to be used for extended desktop, in a similar way to AirDisplay (Section 3.3). AirParrot installs a driver on the control computer, and transmits the output of a virtual second monitor to the Apple TV. Video content can be played using familiar tools such as Isadora or Millumin.

One advantage that AirParrot has over AirDisplay is the ability to use the wired network connection on the Apple TV, over the wireless-only connection of the iPad. (Alternatively, the AirDisplay client can be used on a Mac for a wired AirDisplay solution, however that requires a full computer system which could be better used for native video playback.)

Image: Squirrels LLC.

For Mac or PC – $9.99

5. Notable Technologies

5.1. DisplayLink

While not directly related to wearable or network video, DisplayLink is a notable technology that provides additional video outputs from any USB port. DisplayLink technology is available in a variety of adapters, ranging in price from $30-$150.

These devices allow lower-end laptop computers to output to several projectors or video devices on stage. Newer adapters support greater than HD resolution output.

A typical DisplayLink adapter.

DisplayLink is not a direct replacement for dedicated video outputs, as these devices use video compression to reduce bandwidth over USB. Even with compression, frame rates can suffer depending on the capability of the host computer, resolution, and output content. It is important to test the device thoroughly before using it in a production to ensure it meets your performance requirements. One appropriate use of DisplayLink adapters is for the control screen on a multi-head system. For example, on a Mac Pro with 3 outputs, a USB to DVI adapter could be used for the operator interface, freeing up all three discrete outputs for stage-facing outputs.

Drivers are required for the DisplayLink devices to operate, and are available for Windows and Mac. As of this writing up to 6 DisplayLink devices can be used simultaneously on Windows, or up to 4 on the Mac.

Visit http://www.displaylink.com/shop/adapters for a listing of all DisplayLink models.

5.2.   Intel Next Unit of Computing (NUC)

The Intel Next Unit of Computing was released in December 2012, and is unique as it contains a full-scale Intel i5 processor, comparable to what you would find in a medium-end laptop of today. It has Intel 4000 graphics, which are powerful enough to playback HD video comfortably with effects. What is particularly innovative is that Intel sells the processor, motherboard and power supply as one unit, leaving the end user to add storage via mSATA (a special connector for solid state memory) and RAM memory, plus a power cord.

What differentiates it from the Atom-based small form factor PCs that have been out for a few years is that it is designed to be a desktop replacement, not a low-end PC. It is marketed with a mid-range processor, as opposed to a low end one.

Benefits of using the NUC over a traditional media server system would include ability to store the unit closer to the output device, reducing the need for stage space and expensive video extension cables. All media servers could be mounted directly onto the projector or video device, and a collection of them could be

Two Intel NUC models courtesy
LegitReviews.com / Intel

controlled via a single network cable run to FOH. The NUC is particularly well suited to replace existing media servers, as they are equipped with dual HDMI outputs, and are able to run the latest versions of Microsoft™ Windows®.

Comparable in price to Mac Mini, but more compact, and customizable for theatrical use.

Starting at $299, not including storage or memory.

5.3.   Dataton WATCHPAX

Announced in January 2013, the Dataton Watchpax is compact solid-state media server that runs the proprietary WATCHOUT media server software. Exactly the same cost as buying a single dongle ($2249) from Dataton for a traditional media server, the device can perform the same functions as an ordinary media server. It is low power and is equipped with a single video output.

A single Dataton Watchpax node.

While it remains an expensive choice for theatre, the WATCHPAX demonstrates how industry is adopting low-power, network-based media devices for video playback. Taking advantage of similar hardware decoders and low-power chips that run the Raspberry Pi, the WATCHPAX offers similar advantages in remote operation and scenic integration.

6.   Conclusions

As embedded computers and devices have appeared on the market, so too have applications and frameworks that make them useful for theatrical applications.

Integrating physical technology onto the performer is facilitated by the creative coding movement (Arduino) as well as a push towards the Internet of Things (Raspberry Pi). Universal access to video has spearheaded video software that adds interest to the narrative of our theatrical productions.

Theatre companies are at a unique advantage, in that they can prototype ideas and use them in final productions, quicker than the processes of commercial products. With the low cost of experimentation (Raspberry Pi, iOS Apps), there is no reason for regional-sized theatres not to explore the possibilities of physical computing and network video in their shows.

7. APPENDIX A : Network Considerations

7.1. Network Suggestions

As many of the computer systems discussed in this report rely on communication amongst each other, network design is key to proper operation. While network design can be a complex task, it is important to understand the basics so as to build a theatre network for optimal performance.

Unless absolutely necessary, prefer to use wired ethernet connections over wireless. They offer lower latency (delay), are less prone to interference, and require less setup.

As of this writing, gigabit (1000 Mbps) routers and switches are affordable and accessible. They offer 10 times the transfer speeds of older 100 Mbps equipment, making video transfers immediate. Avoid purchasing equipment with anything below gigabit speeds.

When planning out a theatre network, unifying the devices on a single network is typically beneficial. Video content creation machines, playback computers, wireless remote devices and output devices such as projectors and TVs all benefit from being networked together. Productivity is enhanced when content can be quickly copied amongst computers, and projectors can be controlled from any device.

Seek out devices that are Ethernet/IP-enabled. This is one of the benefits of Raspberry Pi, as it can turn any electronic device into an IP-controlled device.

By using a dedicated gateway/router running pfSense or similar firewall software, you can improve DHCP address allocation and assign fixed IP addresses to devices, without having to assign them statically using complex configuration methods. This also provides the added benefit of being able to control what devices have access to the Internet, and segregate the network from outside threats.

Use network scanners such as fing or Angry IP Scanner to quickly identify machines on a network.

7.1. Wired Tips

To improve transfer of large, contiguous files over gigabit connections, consider using Jumbo Frames or 9000-size packets. In order to be effective, both sides of a connection must support them and have them enabled. Consult the network interface configuration on your device for more information.

Use *iperf* or similar tools to measure network throughput, identifying slow links in your network.

Choose gigabit switches over routers. Home routers are primarily designed as gateways, adding cost to the purchase and adding a step in the configuration process.

7.1. Wireless Tips

Where budgets permit, choose professional wireless access points over consumer-grade wireless equipment. These typically come from brands such as Cisco or Ubiquiti, and offer better network throughput, improved reliability, and superior management features.

In particular, most support 802.3af Power over Ethernet, which greatly simplifies cabling and deployment by eliminating the need to supply power at the Access Point. Where multiple access points are required to provide best coverage of a theatre space, management software can optimize "hops" and signal power.

To ensure devices do not share channel bandwidth, assign different channels to different SSIDs, and select distinct SSIDs for each device or groups of devices. Keep in mind, devices connect to the strongest signal, but do not "hop" until they can no longer connect to their current AP.

Place access points as close to the stage or performance area as you can.

When adding a consumer-grade wireless router to an existing network, always connect the incoming network line to one of the "LAN" ports on the device, and disable DHCP on the device. This will allow wireless devices to operate on the upstream network, rather than a subnet.

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