EXAMINING THE USER EXPERIENCE IN THREE
COMPUTER MUSIC IMPLEMENTATIONS

by

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requirements for the degree of Master of Music.

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Abstract

This work analyzes the ramifications and contexts in which three types of musicians, K-8 students, church musicians and graduate composers and scholars interface with and use computer music installations. By examining an Ubuntu Studio installation in an elementary school, a theoretical Hauptwerk Digital Organ installation in a Roman Catholic Church, and the Peabody Computer Music studio suite, one can come to a definition of what makes a user experience functional and easy to use.

Primary Reader: Dr. Geoffrey Wright

Secondary Reader: Dr. McGregor Boyle
Acknowledgments

I would like to thank Dr. Stephen Gorbos, Assistant Professor of Music at the Catholic University of America, for first introducing me to and getting me excited for the idea of computer music; Dr. McGregor Boyle for assisting me in the development of my programming skills; Wendy Cottrell, principal at Our Lady of Victory Catholic School, for allowing me the latitude to implement a completely new and original curriculum; Michelle Datz, art teacher and my teaching mentor at Our Lady of Victory Catholic School, for her critiques and support of this elementary curriculum; and the students and faculty of Our Lady of Victory Catholic School in Arbutus, Maryland for being so supportive of my efforts.

In a very special way, I also would like to thank Dr. Geoffrey Wright, Director of Computer Music, at Peabody Conservatory, for his invaluable guidance and support throughout this work and in so many other ways, as well as Prof. Michael Hersch, Chair of Composition at Peabody Conservatory, for his assistance and instruction during my three years at the Peabody Institute.
Dedication

This work is dedicated to the students of the Peabody Computer Music department. I hope the work that I have done continues to unlock your creativity and allows you to continue “looking towards the future” for many years to come.
Contents

Abstract ii

Acknowledgments iii

List of Tables ix

List of Figures x

1 Introduction 1

2 Evaluation Of The Hauptwerk Digital Organ System For Use In
Roman Catholic Worship 3

2.1 Research Objective ............................................ 3

2.2 Abstract ......................................................... 4

2.3 Introduction ..................................................... 4

2.4 About the Hauptwerk Digital Organ ............................ 7

2.5 Review of the Product ........................................... 9
CONTENTS

2.6 Compliance with the “General Instruction of the Roman Missal” (GIRM) 11
2.7 Haptic Responses from the Hauptwerk .............................. 12
2.8 Flaws in the UX (User Experience) ................................. 13
2.9 Conclusion .............................................................. 14

3 A Pilot Program For Teaching Electronic Music In Middle School

Education 17

3.1 Research Objective .................................................... 17
3.2 Abstract ................................................................. 18
3.3 Introduction ............................................................. 18
3.4 Background of the CARITAS Program ............................ 20
  3.4.1 Genesis of the CARITAS Program ............................. 20
  3.4.2 Application to Educational Standards ......................... 21
3.5 Historical Inspirations for the Method ............................ 23
  3.5.1 Jean Eichelberger Ivey and the Peabody Institute .......... 23
  3.5.2 Limitation of the Ivey Method ................................. 25
  3.5.3 Morton Subotnick’s “Making Music” Software ............... 26
  3.5.4 Problems with the Software ................................... 28
3.6 Implementing the CARITAS Method ............................... 28

4 The Upgrade of the Peabody Computer Music Studios to Enhance

Workflow and User Experience 34
CONTENTS

4.1 Research Objective ............................................. 34
4.2 Abstract ......................................................... 35
4.3 Introduction ..................................................... 35
4.4 System-Wide Upgrades ........................................... 37
  4.4.1 The Mac Mini Server ........................................ 37
  4.4.2 OpenLDAP ................................................... 38
  4.4.3 Fixed DNS Names ........................................... 39
  4.4.4 CUPS ......................................................... 40
  4.4.5 iTunes Media Server ....................................... 42
  4.4.6 Remote File Sharing ....................................... 44
  4.4.7 Shared Home Folders ....................................... 44
  4.4.8 Group Directories ......................................... 45
  4.4.9 Apple’s Mobile Device Management Software ............ 45
  4.4.10 Securing the Client Machines ............................. 46
  4.4.11 MatLab ..................................................... 47
4.5 Web Presence ..................................................... 47
  4.5.1 WordPress .................................................. 48
  4.5.2 The OS X Wiki .............................................. 49
  4.5.3 User Webpages ............................................. 51
  4.5.4 Booked ..................................................... 51
4.6 Changes at the Studio Level ................................. 51
## CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.6.1 Digital Arts Studio (307)</td>
<td>52</td>
</tr>
<tr>
<td>4.6.2 Digital Performance Studio (309)</td>
<td>52</td>
</tr>
<tr>
<td>4.6.3 Production Studio (312)</td>
<td>53</td>
</tr>
<tr>
<td>4.6.4 Teaching Studio (314)</td>
<td>53</td>
</tr>
<tr>
<td>4.7 PCM: The Next Steps</td>
<td>54</td>
</tr>
<tr>
<td>4.7.1 Technological Shifts</td>
<td>54</td>
</tr>
<tr>
<td>4.7.2 Cultural Shift – Bring Your Own Device</td>
<td>56</td>
</tr>
<tr>
<td>4.8 Conclusion</td>
<td>56</td>
</tr>
</tbody>
</table>
List of Tables

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Comparison between the Music Education Standards of the Archdiocese of</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Baltimore(^1) and the State of Maryland.(^2)</td>
<td></td>
</tr>
<tr>
<td>3.2</td>
<td>The CARITAS Curriculum</td>
<td>30</td>
</tr>
</tbody>
</table>

---

List of Figures

2.1 The Audio Configuration Window of Hauptwerk . . . . . . . . . . . . 10
2.2 The Swell stopjamb in Hauptwerk, can be controlled via touchscreen 10

3.1 A simple example of “piano-roll notation”. The length of the horizontal lines indicates duration, the height on the page indicates pitch. Pitch velocity is not shown in this figure. . . . . . . . . . . . . 19

4.1 A client machine connecting to the PCM iTunes server . . . . . . . 43
4.2 The PCM WordPress Administrator’s Dashboard . . . . . . . . . . . 49
4.3 The PCM Wiki Homepage . . . . . . . . . . . . . . . . . . . . . . . . 50

Chapter 1

Introduction

This research portfolio contains three papers representing the culmination of a year of research into how different types of musicians use and interface with digital technology. The three papers study resource needs and the user experience in systems intended for church performance, post-secondary education and studio work, and kindergarten through eighth grade (K-8) classroom teaching.

The papers are unified in their discussion of user interface and experience (UX). A key part of system design is how the user will access it, and this is the principal question I raise. From the point of views of K-12 educators, performers (with limited computer music training), researchers in a major institution, and the workgroup of researchers interfacing with a larger enterprise, how can systems best be designed and secured to accommodate those needs?

Different digital music applications require different levels of system access, usage
CHAPTER 1. INTRODUCTION

requirements and software. In the first instance, a digital instrument, the Hauptwerk Organ system is reviewed as a potential candidate for use in Roman Catholic parishes. Here, the interface is examined from both a theological perspective as well as a user perspective. Concerns over use and stability are addressed, as well as the difficulty of setting the system up.

Secondly, the “Ubuntu Studio” Linux distribution is examined for the potential of teaching music composition in the middle school classroom. A sample curriculum is given including assignments.

Lastly, this paper examines the Peabody Computer Music Department’s computer network and the implementation of a gigabit local area network (LAN) which I oversaw as part of my graduate assistantship. The article examines many of the choices that were made and why they were made for the best performance, security, and user accessibility of the Peabody Computer Music department.
Chapter 2

Evaluation Of The Hauptwerk

Digital Organ System For Use In

Roman Catholic Worship

2.1 Research Objective

This article is intended for publication in the Concilium Journal, a journal of Roman Catholic theology.¹

CHAPTER 2. EVALUATION OF THE HAUPTWERK DIGITAL ORGAN SYSTEM FOR USE IN ROMAN CATHOLIC WORSHIP

2.2 Abstract

As technology advances, many churches are considering replacing dated digital organs or purchasing an organ for the first time. The purpose of this article, is to review the Hauptwerk Digital Organ system in the context of Roman Catholic worship theology, and to review its appropriateness as an instrument of liturgy in the Roman Catholic church. Because of the communal nature of Catholic theology, the human factors involved with the Hauptwerk system have to be analyzed from two consecutive points of view, the musician who will be rendering service to the community on the instrument, and the Church itself, which (according to Catholic doctrine) takes an active role in worship through its ministers and congregants.

2.3 Introduction

The Concilium Oecumenicum Vaticanum Secundum (Second Vatican Council), which lasted from October 1962 to October 1965, brought about significant changes to the Roman Rite of the Catholic Church, three of which can be directly attributed to a rethinking of Catholic music and architecture. These are: (1) a change in the direction of the priest from ad orientum (facing the altar, away from the people) to versus populum (facing the people), (2) a change in the liturgical language from Latin to the vernacular, and (3) a relaxation on which instruments other than the organ that were allowed to be used in worship.
CHAPTER 2. EVALUATION OF THE HAUPTWERK DIGITAL ORGAN SYSTEM FOR USE IN ROMAN CATHOLIC WORSHIP

The Roman Catholic Church bases its stance on what constitutes “appropriateness” for its sacred vessels and spaces on the biblical story of Cain and Abel.

In the course of time Cain brought an offering to the Lord from the fruit of the ground, while Abel, for his part, brought the fatty portion of the firstlings of his flock. The Lord looked with favor on Abel and his offering, but on Cain and his offering he did not look with favor. So Cain was very angry and dejected.²

The Church uses this quotation to justify its stance that spaces, instruments and sacred vessels used in worship must be of the highest quality for use in its worship. While the Second Vatican Council allowed an expansion of the use of instruments other than the organ to be used in liturgy, the norm that the instruments and performers be of a certain quality applies. For a Hauptwerk installation to be a valid instrument in Catholic liturgy, it must not only be aesthetically integrated into a space, but also be a stable performing platform for use in services.

Because of these changes, newly commissioned churches were no longer uniformly designed in a traditional cruciform structure, and the organ was no longer built as a centerpiece of the church. Simultaneously, due to the rise of the microchip, digital organs, such as the Allen Digital Computer Organ of 1965 began to be incorporated into Catholic Churches as a cost saving measure. These instruments showed significant budget reduction potential both initially and overtime. An acoustic instrument that may have cost over $125,000 could now be obtained by a small rural church for much less than that in digital form. Furthermore, digital organs do not have pipes

CHAPTER 2. EVALUATION OF THE HAUPTWERK DIGITAL ORGAN SYSTEM FOR USE IN ROMAN CATHOLIC WORSHIP

to tune or motors, pistons and slats to keep in working condition, further reducing ongoing maintenance costs of these large and complicated instruments.

Two problems exist with these early digital instruments. First, like all electronic technology, they have a limited life span. Secondly, as technology and digital signal processing algorithms have improved significantly in the last five years, the sound quality of the early instruments is notably lower than current capabilities. This can be likened to upgrading to the latest television or cellular phone; as the technology improves, were one to obtain a newer device, they would likely notice clearer pictures or crisper phone conversations. The same is true with sound. As sound synthesis technology improves, so our ears have become attuned to hearing better and better quality sounds not delivered by the early technologies.

This is not to say that current trends in the digital organ world are not creating truly beautiful and edifying instruments, indeed they are. However, these organs are in many ways more complex and require just as much maintenance as their acoustic counterparts (albeit electronics and electrical as opposed to mechanical and tuning), leading to unexpected costs further down the line. As churches struggle with shrinking budgets and falling membership numbers coupled with liturgical instruments which are breaking down, as well as the empowerment of the lay parishioners to overtake some of the financial duties of the parish by the Second Vatican Council,

3. As a benchmark, the website for Allen Digital Organ lists their smallest organs as starting at around $16,000, not including ongoing maintenance commitments. As the cost is variable based on the space the instrument is intended for, it was not necessary or possible to obtain a quote from Allen Digital Organ for the purposes of this article.

6
churches have a budgetary obligation to question the merits of upgrading to the latest digital organ system from a major manufacturer, as these instruments are costly, large, unable to be moved easily, and often require ongoing maintenance commitments with the companies that build them.

The Hauptwerk Digital Organ system may provide an answer to these problems. A recent article in the Catholic Sentinel⁴, the official newspaper of the Archdiocese of Portland, spoke of a small rural church which had installed a Hauptwerk Organ system in their church, as this was the best option that the parish council could afford under its tight financial circumstances. The article notes the significant cost savings for the parish, stating “including the remodel efforts, the entire project cost around $6,200, an amazingly low figure for a pipe organ. The St. Wenceslaus [sample bank] plays and sounds so much like a real pipe organ that, to the untrained ear, its nearly impossible to tell the difference, parishioners say.”⁵

2.4 About the Hauptwerk Digital Organ

The Hauptwerk digital organ is not a traditional organ console, but a software sequencer and synthesizer. The Hauptwerk software system consists of two parts: the Hauptwerk engine, designed by Milan Digital Audio in Noblesville, Indiana,⁶ and a

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⁵. Ibid.
sample library of the user’s choice, either from Milan Digital Audio, or other companies which have programmed their libraries to be compatible with the Hauptwerk engine base, such as Sonus Paradisi. These libraries are sampled from actual instruments, not synthesized and generated, as opposed to the Allen Digital Organ, which uses a process called DSP Tone Generation which creates the sounds of the various stops and ranks of the organ from scratch and in hardware. Although Hauptwerk was originally designed for sequencing in recording studios, Hauptwerk does include the ability to connect to a variety of MIDI devices, including pedal boards, keyboards, computerized piston banks, and swell shoes. Additionally, Milan Digital Audio itself recommends that touchscreen monitors be used to emulate left and right stopjambs.

It is this modularity however that is Hauptwerk’s greatest strength and weakness. While a modular system can be desirable in that parts can be replaced if they are damaged, or expanded if needed, and that the number of sample libraries themselves is limited only by storage space on a given computer, configuring Hauptwerk, even on a simple testing setup, is a particularly tricky and sensitive process. The Portland-area parish mentioned earlier was in a unique situation in that a member of the congregation was an electrical engineer and computer programmer who donated his time to build this instrument for them. Most parishes, however, would not be so lucky. This article, therefore, looks to review Hauptwerk from the perspective of a music director with limited computer knowledge to determine whether this product

can be recommended for a church as a solution that comes prebuilt and pre-configured to be used immediately as an organ.

2.5 Review of the Product

The Hauptwerk installation process is a simple enough one; Hauptwerk requires a large memory and disk space commitment.\(^8\) Configuration, however, is particularly challenging, requiring an in-depth knowledge of the MIDI specification. Even with this knowledge, it took several attempts to get the keyboard to control the Great manual in Hauptwerk. The setup used in testing was not a complete setup, only using a single keyboard to control one virtual organ manual, and it was disconcerting that the software took as much configuration as it did to work as intended. Once fully set up, however, the sampled libraries were of a high quality. The detail was noticeable and well done. The concern, therefore was not what the software was difficult at, but the amount that it could do. For a studio musician, the ability to control each sampled note is welcomed. For a church musician, however, this detail presents an additional learning curve that can be difficult to overcome. Secondly, the amount of detail that Hauptwerk allows one to change is a concern in that some of the given options, if changed, could cause the Hauptwerk system to stop working entirely. While control over an environment is a feature that Hauptwerk touts as part

\(^8\) For the purposes of this article, Hauptwerk 4.1.1 was tested on a 2.7 GHz Intel Core i5 iMac running OS X Mavericks 10.9.4, using an Edirol UM-2EX MIDI interface and a Roland Keyboard as a MIDI interface.
CHAPTER 2. EVALUATION OF THE HAUPTWERK DIGITAL ORGAN SYSTEM FOR USE IN ROMAN CATHOLIC WORSHIP

Figure 2.1: The Audio Configuration Window of Hauptwerk

Figure 2.2: The Swell stopjamb in Hauptwerk, can be controlled via touchscreen
of its advanced nature, this may be undesirable in a worship environment.

2.6 Compliance with the “General Instruction of the Roman Missal” (GIRM)

According to the General Instruction of the Roman Missal:

313. The organ and other lawfully approved musical instruments should be placed in a suitable place so that they can sustain the singing of both the choir and the people and be heard with ease by everybody if they are played alone. It is appropriate that before being put into liturgical use, the organ be blessed according to the rite described in the Roman Ritual.\footnote{Congregation for Divine Worship and the Discipline of the Sacraments, “General Instruction of the Roman Missal,” chap. 5, Third Edition (United States Conference of Catholic Bishops, 2011), Regulation 313, \url{http://www.usccb.org/prayer-and-worship/the-mass/general-instruction-of-the-roman-missal/girm-chapter-5.cfm}.}

The modular nature of the system does not immediately lend itself to full GIRM compliance. Earlier in the document, the GIRM recommends that the organ be integrated fully into the architecture of the church. For this to happen, a cabinet would need to specifically be built or purchased for the Hauptwerk equipment needed to run the software. While this is not impossible, this adds an additional layer of cost that must be taken into account by any parish council. However, using Martin Digital Organ’s “DIY Hauptwerk Kit,” I was able to assemble a Hauptwerk console for under $10,000, a significant improvement over a solid state organ. In this installation, the church is responsible for ordering all the parts, including MIDI interfaces, keyboards, casings, and computers. Affordability, however, does have its costs. Because the
church musician may or may not be familiar with the intricacies of building a responsive MIDI-based instrument, it is not unreasonable for a church to question the need for a piece of software, refrain from ordering it, and discover that their system does not work as anticipated.

2.7 Haptic Responses from the Hauptwerk

In her article “Haptic Augmentation of the Hybrid Piano”, Lauren Hayes notes

The enactive approach to understanding and creating music...[suggests] that our cognitive processes have their roots within the multimodal capacities of the body as a whole, and that meaning can be elicited through our bodily interactions with the world. These ideas have gradually started to permeate the field of digital instrument design, especially in relation to haptic and tangible technology, where the emphasis on the interdependent relationships between body and mind is taken as key to suggesting improved ways in which novel digital musical instruments (DMIs) might be conceived, in order to create more potential for expression and a more engaged performance both from the point of view of the performer and of the audience.

The lack of haptic feedback from the instrument without using specialized is the fundamental issue with Hauptwerk. Traditionally, organists are trained to rely on haptic feedback to orient themselves to the console. A touchscreen interface eliminates that response, and thereby removes that functionality from an organist’s training. The fact that a low-cost implementation would likely rely on the built-in touchscreen interface is an issue that would likely cause organists to simply avoid using the instrument. This is a fine solution for a casual player, however, a seasoned organist would likely
CHAPTER 2. EVALUATION OF THE HAUPTWERK DIGITAL ORGAN SYSTEM FOR USE IN ROMAN CATHOLIC WORSHIP

have difficulty adjusting to this interactive paradigm. The reason for this is because an organist is trained to operate on a simple haptic-response system: the stopjamb. By removing this, the musician is left to rely on a non-responsive touch screen to re-voice the instrument.

2.8 Flaws in the UX (User Experience)

Complexity in the user interface is one of the most difficult aspects of Hauptwerk for a church musician, particularly in the Roman Catholic tradition. Prior to the reforms of 1970, only the organ and the violin were permitted as principal instruments in worship. However, even in this post-conciliar age, the simplicity of instruments is still seen as a serious requirement for Roman Catholic worship; indeed, the GIRM makes significant mention of the simplicity of instruments and their role not to distract but to enhance. This is where Hauptwerk fails. The interface itself is complex for a church musician without specialized training in computer music usage and system maintenance. For the purposes of a composer relying on the software’s sequencing abilities, Hauptwerk’s details are important, as they allow the studio technician to tune or de-tune a rank of pipes as needed. However, this level of complexity is unnecessary in the church environment.

11. Ibid.
CHAPTER 2. EVALUATION OF THE HAUPTWERK DIGITAL ORGAN
SYSTEM FOR USE IN ROMAN CATHOLIC WORSHIP

2.9 Conclusion

Several problems exist with the inclusion of the Hauptwerk Organ System in Roman Catholic Worship. In Roman Catholic theology that concerns the use of musical instruments in the liturgy, both the aesthetic and the practical considerations must be taken into account as they are inseparable. From the theological perspective, it seems unlikely that, in its most basic form, the Hauptwerk System is appropriate for Roman Catholic worship. This is not to speak to individual implementations, however. While great care may have been taken in specific installations, factory configured Hauptwerk is not immediately fit for this goal.

Because the purpose of this theoretical installation is the act of worship, two specific user groups must be analyzed for the way that they interface with the instrument: that of congregants and organist. From the perspective of the congregants, two particular issues immediately arise. Firstly, it is unlikely that a church looking to utilize this system for budgetary reasons will take into consideration the aesthetic implications of the system. Instead, the system will likely be poorly designed and not be in compliance with the GIRM directive that the organ be integrated into the worship space with purpose and prominence, reflecting its special purpose and mission in Roman Catholic liturgy. Secondly, for budgetary reasons, if a congregation cannot afford a base computer terminal with the proper specifications to run the software or designs a poorly ventilated organ console, problems such as sample distortion, loss of voicings, and in extreme cases, a kernel panic could potentially occur, rendering the
instruments usable for 5 to 7 minutes while a reboot happens. This is unacceptable in a worship situation. An even worse possibility could be a situation wherein the startup sequence rejects all peripherals and refuses to boot until the peripherals, such as an audio/MIDI interface, are disconnected. This could, in some situations, require a disassembly of the console during a worship service, which would cause the congregation to lose its primary instrument of vocal accompaniment.

The primary difficulty for the musician is that in the configuration and installation, Hauptwerk is a complicated piece of software relying on the outmoded MIDI standard for communication, which requires a high level of MIDI programming skills to properly configure. These are skills that would likely be not common to most church musicians.

A second, yet unavoidable issue is that of a lack of haptic feedback (again, in factory configuration) from stopjams, toe stops and pistons that an organist would encounter on a standard console. Instead, Hauptwerk relies primarily on a touchscreen-based interface, which could make quick piston changes difficult, if not impossible.

The quality of samples aside, any congregation seriously considering Hauptwerk as a viable alternative to a solid-state organ should strongly consider the issues in the user interface, the complexity of setup and a lack of out-of-the-box haptic feedback.

A better option for most churches who are insistent upon having the flexibility of Hauptwerk might wish to consider a less difficult approach than assembling their own instrument. Aside from those instances, Hauptwerk might best be suited towards a studio environment where the UX will be a familiar one to a well-trained computer.
CHAPTER 2. EVALUATION OF THE HAUPTWERK DIGITAL ORGAN SYSTEM FOR USE IN ROMAN CATHOLIC WORSHIP

musician.
Chapter 3

A Pilot Program For Teaching

Electronic Music In Middle School Education

3.1 Research Objective

This article is intended for publication in the Journal of the National Association for Music Educators.¹

CHAPTER 3. A PILOT PROGRAM FOR TEACHING ELECTRONIC MUSIC IN MIDDLE SCHOOL EDUCATION

3.2 Abstract

This article examines a solution for teaching technology-based music in a Title 1 K-8 music classroom.

3.3 Introduction

In the summer of 2014, I was hired to teach part-time music for Pre-Kindergarten through Eighth Grade students at Our Lady of Victory Roman Catholic Elementary School in Arbutus, Maryland. This position entailed teaching general music across the curriculum with a particular emphasis on voice, as well as drama. Because the school is a technology-centric environment, I was immediately intrigued with the possibility of teaching computer music composition to students at this level. The curriculum required that I teach some form of improvisatory composition and I began to explore various methods of teaching this craft.

One of the largest obstacles in teaching this portion of the curriculum was the lack of knowledge of reading traditional Western music notation. Due to shifting requirements at the state level and a turnover in faculty, students had not had consistently received musical training throughout their years in the school. This was particularly noticeable in the upper-level grades. For this reason, I conceived the idea of teaching the composition-oriented portion of the curriculum using computer technology and piano-roll notation, and I developed the CARITAS (Collaborative Audio Recording
and Interactive Teaching for All Students) method to assist in that goal.

Figure 3.1: A simple example of “piano-roll notation”. The length of the horizontal lines indicates duration, the height on the page indicates pitch. Pitch velocity is not shown in this figure.

Piano-roll notation was specifically chosen because of its use of graphics to indicate pitch, duration, rhythm, and velocity. For a non-musical reader, this notation is more intuitively obvious than traditional music notation, and also serves to relate the information to its location on a piano keyboard, which in itself can be a bridge to understand traditional notation. Additionally, because of the ubiquity of mobile devices among our student population, I noticed that students had a particular proficiency in this type of notation, as it is used in simple sequencers such as Apple’s Garageband, which many of the students have access to.
3.4 Background of the CARITAS Program

The CARITAS method was developed out of a necessity for reaching students in a Title I Roman Catholic Elementary school. According to the United States Department of Education,

Title I, Part A (Title I) of the Elementary and Secondary Education Act, as amended (ESEA) provides financial assistance to local educational agencies (LEAs) and schools with high numbers or high percentages of children from low-income families to help ensure that all children meet challenging state academic standards. Federal funds are currently allocated through four statutory formulas that are based primarily on census poverty estimates and the cost of education in each state.\(^4\)

At Our Lady of Victory Elementary school, many students are on some form of financial aid. The students are drawn primarily from the West Baltimore neighborhoods of Edmonson Village and Violetville. For their families, the Catholic Educational system is seen as an alternative to the high-crime zoned public schools.

3.4.1 Genesis of the CARITAS Program

CARITAS, latin for “charity towards humankind” and standing for Collaborative Audio Recording and Interactive Teaching for All Students, is a method which integrates music technology into the 6-8th grade music curriculum. The word “caritas” was chosen to reflect the collaborative nature of the project, which requires students to work in small groups to compose. During the first week of school, I quickly learned

that in the middle school grades, most students had only a limited working knowledge of standard Western musical notation, no understanding of Solesmes 4-line notation (which is still technically a sub-requirement of the Archdiocese of Baltimore), and limited knowledge of performance practices. Because of this, in conjunction with the school administration, the decision was made to shift the focus from traditional musical notation to piano-roll notation, a visual form of proto-musical notation which uses horizontal lines to denote duration of pitches and is common in digital audio workstations. By removing a fluency barrier to the language of music, it was hoped that students would be able to better and more fully express themselves in a compositional activity.

3.4.2 Application to Educational Standards

The CARITAS PROGRAM is compliant with both Maryland State Educational Standards and the Archdiocese of Baltimore’s Standards for Pre-K to 8 Music Education. The program was conceived as a necessity as a response to the lack of notation skill held by students and their proficiency at technology based learning.

The Archdiocesan Collaborative School environment is a unique teaching environment in that all taught standards in all subjects must tie to religious standards of “faith in practice”, as shown in Table 3.1.

Note that the primary development of CARITAS was not to create a curriculum exclusive to Catholic Education, the very nature of the environment in which it
### Table 3.1: Comparison between the Music Education Standards of the Archdiocese of Baltimore and the State of Maryland

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<thead>
<tr>
<th>Maryland State Standards for Music</th>
<th>Archdiocese of Baltimore Standards for Music</th>
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<tr>
<td><strong>1. Perceiving, Performing, and Responding:</strong> Aesthetic Education: Students will demonstrate the ability to perceive, perform, and respond to music.</td>
<td>1. Sings alone and with others a varied repertoire of music.</td>
</tr>
<tr>
<td><strong>2. Historical, Cultural, and Social Context:</strong> Students will demonstrate an understanding of music as an essential aspect of history and human experience.</td>
<td>2. Performs on instruments, alone and with others, a varied repertoire of music.</td>
</tr>
<tr>
<td><strong>3. Creative Expression and Production:</strong> Students will demonstrate the ability to organize musical ideas and sounds creatively.</td>
<td>3. Improvises melodies, variations and accompaniments.</td>
</tr>
<tr>
<td><strong>4. Aesthetics and Criticism:</strong> Students will demonstrate the ability to make aesthetic judgments.</td>
<td>4. Composes and arranges music within specific guidelines.</td>
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<tr>
<td><strong>5.</strong> Reads and notates music.</td>
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<tr>
<td><strong>6.</strong> Listens to, analyzes and describes music.</td>
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<tr>
<td><strong>7.</strong> Evaluates music and music performances.</td>
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<tr>
<td><strong>8.</strong> Understands relationships between music, the other arts, and disciplines outside the arts.</td>
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<tr>
<td><strong>9.</strong> Understands music in relation to history, culture, liturgy and our Catholic Identity.</td>
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Table 3.1: Comparison between the Music Education Standards of the Archdiocese of Baltimore and the State of Maryland.
CHAPTER 3. A PILOT PROGRAM FOR TEACHING ELECTRONIC MUSIC IN MIDDLE SCHOOL EDUCATION

was conceived required curricular tie-ins to the theology curriculum of the Catholic elementary school system. Note that because the CARITAS method meets the standards set forth by the Archdiocese of Baltimore, it also exceeds the standards set forth by the state of Maryland. Thus, this method can be implemented in both a public and parochial environment.

3.5 Historical Inspirations for the Method

The idea of using electronics to teach music in the K-12 environment is not new. Two composers in particular are associated with this concept: Jean Eichelberger Ivey and Morton Subotnick.

3.5.1 Jean Eichelberger Ivey and the Peabody Institute

In 1967, the Peabody Conservatory began a series of workshops for Music Educators. These workshops, taught by Dr. Jean Eichelberger Ivey, served as a supportive environment for “those who believed that electronic music had a valid place in the classroom [and] had no way to acquire the background and knowledge needed to teach it.”11 Ivey noted that:

CHAPTER 3. A PILOT PROGRAM FOR TEACHING ELECTRONIC MUSIC IN MIDDLE SCHOOL EDUCATION

For the purpose of the workshop, electronic music was defined as music created in the laboratory using electronic sound generators and techniques made possible by magnetic tape recording. Once sounds have been recorded on tape, it becomes possible to manipulate them in a way that has never been possible before. The sounds themselves may come from everyday life (in what is called musique concrète) or from electrical devices such as oscillators (valued for the extensive range and precise control they afford), or a combination of both. They may include recordings of standard musical instruments, perhaps made to sound as no performer could do; or the final tape may be designed to accompany one or more live performers playing or singing.\textsuperscript{12}

The workshops were noted particularly for their approach to team-teaching by integrating the music curriculum to the science and physics curriculum. Ivey also noted that little to no additional hardware was needed to implement a music technology curriculum at the pre-college level. Ivey stated that “[t]he notion that electronic music demands, as a basic necessity, extremely elaborate equipment like that of the most famous studios is a fairly common fallacy; as a matter of fact, more than one famous studio started quite modestly. Especially at the precollege level, the aim is hardly to provide facilities for the creation of tape masterpieces, but rather to give some familiarity with the processes. A survey of the school may reveal that a surprising number of devices useful in tape composition are already on hand.”

While technology has certainly changed since the 1967 Peabody workshops, much of Ivey’s philosophy was incorporated into the development of the CARITAS method,. It is important to note four thing’s from Dr. Ivey’s research methodology: (1) that in the nascent stages of the genre, application to music education was already being

\textsuperscript{12} Ivey, “Electronic Music Workshop for Teachers.”
examined, (2) that a pre-college environment need not make a significant financial investment in the creation of an electronic music workspace, (3) music education can have a significant place in a science and technology based-curriculum, and (4) that traditional music notation, while important to achieve as a base understanding of the history of western music education, may in fact be a barrier to full participation by those students who do not have behind them years of private or self-directed study in musical notation. To this final point, Ivey notes:

As a creative medium, tape music would be almost equally new to everyone. In the average creative music session dealing with song or instruments as the medium and often utilizing traditional ideas of musical form, pupils with several years’ private lessons and a familiarity with notation may stand out in a way that inhibits those lacking this special training; indeed, this training may act as a somewhat inhibiting factor even to those who have had it, since it induces them to think only along conventional musical lines. Genuine creativity involves being open to the new and the untried. The new medium of electronic music, with its vast possibilities and its lack of a long, well-formulated tradition, may call forth, better than an older medium, a sense of what it is to deal with the unfamiliar in an open and original way.\textsuperscript{13}

### 3.5.2 Limitation of the Ivey Method

The fundamental limits with the method have to do with the passage of time. Because technology has advanced beyond the use of 2-track tape decks and Electro-comp synthesizers, much of Ivey’s methods are no longer feasible. However, her ideas specifically point to an ongoing desire to integrate music into the K-8 classroom and what the future held for Music Education.

\textsuperscript{13} Ivey, “Electronic Music Workshop for Teachers.”
3.5.3 Morton Subotnick’s “Making Music” Software

According to music education scholar Kathleen Manchester, Morton Subotnick’s “Making Music” Software is a software program that allows students to compose by drawing different shapes and colors.\(^{14}\) By working in the visual realm as opposed to western musical notation, Subotnick hopes to eliminate the fluency barrier inherent in western musical notation.

CHAPTER 3. A PILOT PROGRAM FOR TEACHING ELECTRONIC MUSIC IN MIDDLE SCHOOL EDUCATION

According to music education scholar Kathleen Manchester, a typical assignment for a third grade class could look like this:

"Today you will compose a rondo using the computer software Making Music. Follow these steps carefully. If you need help, click on the man’s head for audio help. You can also quietly ask another student or raise your hand and wait patiently for your teacher to be available.
Step 1. Log on to your computer and load the program.
Step 2. Click on the central composition space, which is in the center of the screen.
Step 3. Trash any compositions that may have been left on your screen.
Step 4. Click on the instrument-painting palette and choose a sound. Click on the OK hand.
Step 5. Click on the paintbrush. Move the cursor to the blank composition space, click and hold the button down and move the cursor around the screen. Release the button when done. Use only half of the screen for your composition.
Step 6. Click on the green triangle to hear your composition. Erase all or some of the notes and redo step 5 until you get a sound you like.
Step 7. Click on the first TV screen to save this section of your rondo.
Step 8. Click back in the central composition space, then double click the eraser to clear the screen.
Step 9. Repeat steps 4-7 to create two more sections for your rondo. When you have a section you like, save it in a blank screen. Continue until three screens are filled with different sounds.
Step 10. Now go to the central composition space, clear it, and paste your three sections on the composition space in rondo form. Play your composition and change it as you think necessary.
Step 11. When your rondo is ready, play it for your teacher.
Step 12. At the end of class time, erase your composition space and trash all your screens so they are ready for the next person.
Step 13. Click on the bottom right box to return to the main screen. Then quit the program and log off.  

According to Manchester:

Composing requires advanced thinking skills. “Students put knowledge in use and then evaluate it, using analysis, synthesis, problem solving, categorizing, and classifying”. By using computers, students have access to a

15. Manchester, “A beginner’s guide: computer composition in the elementary music class.”
greater variety of timbres and can make choices based on their sound preferences rather than being assigned instruments based on what is available or what they can play. Students can also create harmony and determine the complexity of the sound by the number of layers they choose to use. By dealing with a specified form, they learn to sequence their ideas within a set of guidelines. It is a concrete, hands-on process in which students can manipulate the sound directly according to their judgment, unlimited by performance considerations. They synthesize their previous experiences with music in evaluating the results of their efforts.\footnote{Manchester, “A beginner’s guide: computer composition in the elementary music class.”}

3.5.4 Problems with the Software

“Making Music” was not a feasible option for Our Lady of Victory School, primarily for budgetary and compatibility reasons.

3.6 Implementing the CARITAS Method

An unused classroom in the school was designated the “Digital Arts Studio”, and 12 surplus computers were inventoried to this room. No additional peripherals such as MIDI keyboards were purchased, as the room is also planned for use by art classes for teaching digital art concepts, as well as the yearbook class, so it was important that multi-purpose functionality was retained. Ubuntu Studio was chosen for its stability, its Linux operating system underpinnings, and its various creative software suites which mirror commercial, closed-source software. The existing installation of Microsoft Windows was removed from these 12 computers and Ubuntu Studio was
CHAPTER 3. A PILOT PROGRAM FOR TEACHING ELECTRONIC MUSIC IN MIDDLE SCHOOL EDUCATION

Ubuntu Studio is maintained by Canonical, Inc., and is the official version of Ubuntu Linux designed for artists, videographers and musicians. It is a professional quality installation that is open-source and completely free to its users. According to the Ubuntu Studio documentation,

Ubuntu Studio is a free and open source operative[sic] system, and an official flavor of Ubuntu. Ubuntu Studio is the most widely used multimedia orientated GNU/Linux distribution in the world. It comes preinstalled with a selection of the most common free multimedia applications available, and is configured for best performance for the Ubuntu Studio defined workflows: Audio, Graphics, Video, Photography and Publishing.

Over the course of the school year, I did extensive research to locate a curriculum based on digital music. While some curricula did in fact exist, many were based on proprietary systems. These systems were often written by textbook companies and taught interfaces that were specifically designed by them. As the purchase of these systems was not an option, I quickly found the need to write my own. Thus, the curriculum for CARITAS, as written by myself, follows below:

18. Ibid.
# CHAPTER 3. A PILOT PROGRAM FOR TEACHING ELECTRONIC MUSIC IN MIDDLE SCHOOL EDUCATION

Table 3.2: The CARITAS Curriculum

<table>
<thead>
<tr>
<th>Week Number</th>
<th>Topic of the Day</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>What is Sound Synthesis?</td>
<td>Student will be able to identify a simple vs. complex waveform. Student will become familiar with the look and feel of the Linux environment.</td>
</tr>
<tr>
<td>Week 2</td>
<td>The Hydrogen Drum Machine – Part 1</td>
<td>Students will become familiar with certain instruments in the Hydrogen Drum Machine environment.</td>
</tr>
<tr>
<td>Week 3</td>
<td>The Hydrogen Drum Machine – Part 2</td>
<td>Students will further their knowledge of the Hydrogen Drum Environment. Students will create a simple beat pattern in the Hydrogen Drum environment and save it to their folder.</td>
</tr>
<tr>
<td>Week 4</td>
<td>The Hydrogen Drum Machine – Part 3</td>
<td>Student will be introduced to basic Mixing and Mastering Concepts. Students will create two more contrasting beat patterns.</td>
</tr>
</tbody>
</table>

Continued on next page
CHAPTER 3. A PILOT PROGRAM FOR TEACHING ELECTRONIC MUSIC IN MIDDLE SCHOOL EDUCATION

Table 3.2 – continued from previous page

<table>
<thead>
<tr>
<th>Week Number</th>
<th>Topic of the Day</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 5</td>
<td>The Hydrogen Drum Machine – Part 4</td>
<td>Students will familiarize themselves with the Song design and export functions of the Hydrogen Drum Environment.</td>
</tr>
<tr>
<td>Week 6</td>
<td>Ardour Part 1</td>
<td>Students will familiarize themselves with the Ardour Digital Audio Workstation. Students will use the Ardour Digital Audio Workstation to make small edits to sound files</td>
</tr>
<tr>
<td>Week 7</td>
<td>Ardour Part 2</td>
<td>Students will continue to familiarize themselves with Ardour Students will use the basic filters (flangers, delays, etc.) in Ardour to change existing sounds</td>
</tr>
<tr>
<td>Week 8</td>
<td>Ardour Part 3</td>
<td>Students will begin to familiarize themselves with the MIDI functionality of Ardour. Students will begin to compose a simple melody in Ardour</td>
</tr>
</tbody>
</table>

Continued on next page
<table>
<thead>
<tr>
<th>Week Number</th>
<th>Topic of the Day</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 9</td>
<td>Ardour Part 4</td>
<td>Students will continue to familiarize themselves with the MIDI functionality of Ardour. Students will complete their Simple Melody to be mixed with their drum track from earlier in the unit.</td>
</tr>
<tr>
<td>Week 10</td>
<td>Hydrogen and Ardour</td>
<td>Students will familiarize themselves with the concept of Application Interconnectivity in the UNIX environment. Students will successfully send data between Ardour and Hydrogen using the JACK module. Students will send their Drum track from Hydrogen to Ardour successfully.</td>
</tr>
<tr>
<td>Week 11</td>
<td>Post-Production</td>
<td>Students will become familiar with basic principles of audio mixing. Students will mix their audio files down to a standard format.</td>
</tr>
</tbody>
</table>
### Table 3.2 – continued from previous page

<table>
<thead>
<tr>
<th>Week Number</th>
<th>Topic of the Day</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 12</td>
<td>&quot;Concert&quot;</td>
<td>Students will share work with each other and critique their peers appropriately.</td>
</tr>
</tbody>
</table>
Chapter 4

The Upgrade of the Peabody
Computer Music Studios to
Enhance Workflow and User
Experience

4.1 Research Objective

This paper is intended for presentation at the 2015 ISMIR (International Society
for Music Information Retrieval) Conference in Málaga, Spain.¹

¹ The International Society for Music Information Retrieval Conference, “ISMIR 2015 Málaga,”
CHAPTER 4. THE UPGRADE OF THE PEABODY COMPUTER MUSIC
STUDIOS TO ENHANCE WORKFLOW AND USER EXPERIENCE

4.2 Abstract

In 2014, the Peabody Computer Music (PCM) department undertook a major
upgrade of systems and facilities by installing a gigabit network and configuring all
its systems to work together in a computer work-group environment. This reconfigu-
ration required a large amount of creativity and dedication to appropriately integrate
the network with the larger Johns Hopkins Computing Enterprise. This paper exam-
ines some of the choices made and the installation procedures used.

4.3 Introduction

Prior to the beginning of the 2014-15 academic year, the Peabody Computer
Music department undertook a long-planned upgrade to its computer systems and
software. This upgrade addressed many usability issues which had occurred prior to
the upgrade, and was designed to increase usership and stability among the various
PCM systems.

As system administrator, I oversaw many of the changes and implemented them
in consultation with Dr. Geoffrey Wright, Director of Computer Music. The purpose
of this paper is to explore the choices we made in our upgrading practices and to doc-
ument these changes for future reference as a studio implementation inside the larger
Johns Hopkins computing environment. It will also explore some of the obstacles
that we encountered during the upgrade.
CHAPTER 4. THE UPGRADE OF THE PEABODY COMPUTER MUSIC
STUDIOS TO ENHANCE WORKFLOW AND USER EXPERIENCE

Founded in 1982 by Dr. Geoffrey Wright, the Peabody Computer Music department consists of a suite of studios and offices on the third floor of the Peabody Institute’s conservatory building. In total, the four studios and one faculty office contain an Apple Mac Mini Server, 3 Apple iMacs, 2 Apple Mac Pro towers, 2 Apple Mac Book Pro’s and an Apple iPad. These studios are used by undergraduate and graduate students in both Computer Music (all concentrations) and Composition for research and composition. Each of the four studios has a designated purpose: the Digital Arts Studio, which is a collaborative learning environment with an emphasis on computer graphics (also known as studio 307), the Digital Performance Studio (studio 309), the Teaching Studio (314), and the Production Studio (studio 312).

In February 2014, an infrastructure upgrade to the Computer Music networking capabilities was completed when a gigabit network and switch were installed. Connected to the Johns Hopkins Enterprise Intranet via fiber optics, for the first time because of it’s gigabit local area network, the Computer Music department now has the ability to stream uncompressed audio with no loss between studios in real time. The Johns Hopkins Enterprise refers to the unified computing systems of all Johns Hopkins University and Hospital campuses throughout the world. Because of the nature of Johns Hopkins as both a University and a Hospital system, significant resources are devoted to network security, as all machines are interlinked. During the summer of 2014, the upgrades to the remainder of studio hardware and software were completed by myself and Dr. Wright.
CHAPTER 4. THE UPGRADE OF THE PEABODY COMPUTER MUSIC STUDIOS TO ENHANCE WORKFLOW AND USER EXPERIENCE

4.4 System-Wide Upgrades

Among the benefits of a dedicated subnet LAN for Computer Music was the possibility of implementing a single-sign-on login system for all computers in the department. This had not previously been an option as PCM did not have a dedicated networking switch with the capability of routing data to our studios. The data had to be sent to a switch located in the Conservatory Information Technology department, and then routed back to our studios, resulting in transfer times too slow for real-time audio usage and precluding the usage of streaming audio technology. At this time, the PCM studios exclusively use Mac OS X for terminals, and so a logical choice was to purchase a Mac Mini server with server software installed to replace an outdated Mac Pro server.

4.4.1 The Mac Mini Server

The Mac Mini Server solution was chosen over another UNIX based solution for two reasons: easy integration with existing systems and the collaborative software which is bundled with OS X Server. Not only does the OS X Server come bundled with web hosting capabilities and other typical server functions such as email (which is not being used in PCM), it also comes with a wiki system (eliminating the need for MediaWiki), a calendaring system (eliminating our reliance on Microsoft Exchange and Google Drive), and the Xcode development environment. As we soon discovered,
due to enterprise restrictions, this may have been the more difficult route as OS X Server was not immediately compatible with security restrictions in place at Johns Hopkins. Certain incompatibilities between an earlier version of the OS X system and the current security needs of the Johns Hopkins University required an immediate upgrade to OS X Yosemite, which was in its final BETA testing at the time.

4.4.2 OpenLDAP

The Single-Sign-On (SSO) login system was implemented around this same time. Using the OpenLDAP protocol, “an open source implementation of the Lightweight Directory Access Protocol”\(^2\), it is now possible to serve all user profiles from the Mac Mini Server. As the number of users on the PCM system is anywhere between 40 and 60 users during the academic year, the use of OpenLDAP proved to be an invaluable time saver. Previously, a user had to be created on each machine. With 7 machines in the department and a large number of students in our lower level classes from outside of the department who require access on a semester-by-semester basis, manually adding all users on every single machine every semester proved a task too big to fail, and yet too big for one person to handle.

The SSO implementation proved to have further reaching consequences than we had anticipated, both positively and negatively. An immediate problem of this implementation was maintaining file integrity. Due to JHU Enterprise security restrictions,

\(^2\) The OpenLDAP Project, “OpenLDAP Software 2.4 Administrator’s Guide,” \url{http://www.openldap.org/doc/admin24/}.
all LDAP implementations within the enterprise must use a specific schema to generate UNIX-style usernames. For simplicity, we chose to generate usernames in “first initial-last name” style. Since no naming scheme was in place prior to implementing the LDAP system, some research into file ownership had to take place to see who was the rightful owner of many files. This also meant file permissions (which were theoretically supposed to remain intact according to Apple documentation) were largely broken, especially on the teaching and production machines.

The second problem arose as a user-interface issue. The Johns Hopkins Enterprise uses an Active Directory system (the Johns Hopkins Enterprise Domain Identification, or JHED ID) which is used to sign into enterprise software and systems. It proved confusing for some members of the department to utilize different log in credentials to studio systems than their university email.

The overall effect of the network updates, however, was mostly positive. Students were able to enter one username and password to log into not only the terminals, but our wiki system, our scheduling system and our WordPress webpage implementation.

4.4.3 Fixed DNS Names

A minor change was made at the enterprise level to assign each and every workstation contained in the department a DNS entry in the Enterprise. DNS is “an abbreviation for Domain Name System, a system for naming computers and network services that is organized into a hierarchy of domains. DNS naming is used in
CHAPTER 4. THE UPGRADE OF THE PEABODY COMPUTER MUSIC STUDIOS TO ENHANCE WORKFLOW AND USER EXPERIENCE

TCP/IP networks, such as the Internet, to locate computers and services through user-friendly names.”³ Accordingly users may access every PCM machine from inside the Enterprise (either off campus via VPN software or on the Johns Hopkins wireless network itself) using a DNS name as opposed to an IP address, a server-assigned set of numbers to locate each machine on the network, for SSH, “a program for logging into a remote machine and for executing commands on a remote machine”⁴, and for SFTP, “an interactive file transfer program...which performs all operations over an encrypted ssh transport”.⁵

4.4.4 CUPS

Because of the integrated network it was also easy to implement CUPS. “CUPS is the standards-based, open source printing system developed by Apple Inc. for OS X and other UNIX-like operating systems. CUPS uses the Internet Printing Protocol (IPP) to support printing to local and network printers.”⁶ CUPS is a terminal-level daemon, “a type of program on Unix-like operating systems that runs unobtrusively in the background, rather than under the direct control of a user, waiting to be activated

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CHAPTER 4. THE UPGRADE OF THE PEABODY COMPUTER MUSIC STUDIOS TO ENHANCE WORKFLOW AND USER EXPERIENCE

by the occurrence of a specific event or condition.”. 7 This daemon, combined with a web interface for management of the backend configuration of the software, allows for easy configuration and distribution of printer information. CUPS allows each of the studio desktops, laptops and tablet devices to print to the single department printer located in Room 307. This was theoretically possible before, however, two major issues prevented this with ease. First, even though the Local Area Network is in many ways independent and has a dedicated subnet of IP addresses, it still receives DHCP information from the Johns Hopkins Network Security Center at the Mount Washington campus. DHCP is a network protocol that enables a server to automatically assign an IP address to a computer from a defined range of numbers...configured for a given network.” 8 Previously, every time the printer was rebooted it would receive a new dynamic IP address from the enterprise, making it difficult to rely on a consistent access to the printer. Second, because CUPS was not activated, the printer could not be found through the graphical control panels contained within OS X. The printer’s IP address had to essentially be hunted down and set, manually, on all department machines every time a new IP address was received by the printer from the DHCP server.

After consultation with Enterprise IT employees, we were able to set the printer to have a fixed IP address by MAC (media access control) address, “a unique numeric code that is permanently assigned to each unit of most types of networking hardware,

CHAPTER 4. THE UPGRADE OF THE PEABODY COMPUTER MUSIC STUDIOS TO ENHANCE WORKFLOW AND USER EXPERIENCE

such as network interface cards...by the manufacturer”⁹ at the Enterprise level. This means that the printer will receive its fixed IP address from the Mount Washington servers directly, and will have the correct IP address after every reboot. With the addition of activating CUPS on the computer music server, the system administrator can additionally control which machines, user groups and users can send documents to the printer, track the number of jobs each user has sent to the printer, and can send changes to the printer remotely over the network through a simple to navigate web interface. CUPS also integrates with OS X’s native Bonjour networking discoverability protocol, which allows the printer to be easily found from within the OS X Printer control panel.

4.4.5 iTunes Media Server

Because of the long history of the Peabody Computer Music department, and because of the multimedia nature of Computer Music, the department has a large amount of historical data in audio-visual format, especially rare recordings of pieces by Jean Eichelberger Ivey and other studio faculty, as well as news footage of various Computer Music events both on and off the Peabody campus. This data has been carefully archived over the years, however not in a format easily accessible throughout the department. The iTunes media server proved to serve this purpose well.

The iTunes media server allows a single computer to share the contents of its

⁹ The Linux Information Project (LINFO), “MAC Address: a unique hardware address,” http://www.linfo.org/mac%5C_address.html.
media library across a wired Ethernet network, both audio and video. When the user launches iTunes on a client machine, the networked media appears automatically without prompting. When a piece of media is selected, it is streamed from the server with as close to a zero loss of quality as made possible by the fast network speed.

Figure 4.1: A client machine connecting to the PCM iTunes server

This type of sharing is advantageous for media over shared folders because users may not copy the materials onto their own computer. Thus, if the media is copyrighted, and only given to the department for academic research purposes, it can be considered accessible but secure and in compliance with Fair Use policies.
CHAPTER 4. THE UPGRADE OF THE PEABODY COMPUTER MUSIC STUDIOS TO ENHANCE WORKFLOW AND USER EXPERIENCE

4.4.6 Remote File Sharing

After the implementation of the fixed DNS names for each machine, it became feasible to activate remote file sharing in two paradigms: shared home folders and shared group directories. These directories can be accessed both on campus, connected to the Hopkins Enterprise network via wired or wireless networking, or off campus through the enterprise-provided VPN software. Students can connect to their directories through the AFP (Apple File Protocol), WebDAV (Web Distributed Authoring and Versioning) or through SMB (Server Message Block) protocols, enabling access to all resources saved on the network on Mac, Windows, Linux, Android and iOS devices.

4.4.7 Shared Home Folders

As part of the upgrade, the department had originally considered the possibility of sharing a users profile and home folders across the network from the server. This would have allowed for a users documents to be located on the server and yet be available from every machine in the department at the time of login. However, concerns about documents such as Logic projects, which may rely on sample libraries which are not installed on all machines, made this approach unfeasible.
CHAPTER 4. THE UPGRADE OF THE PEABODY COMPUTER MUSIC STUDIOS TO ENHANCE WORKFLOW AND USER EXPERIENCE

4.4.8 Group Directories

Group directories are an additional feature allowing us to sort users into groups by classes each student is currently enrolled in. They are then able to connect, again off or on campus, to a single directory which contains resources relevant to each computer music course being offered. Currently, this approach is being used in the History of Electroacoustic Music Class to store articles and large multimedia pieces that would not fit on a Blackboard account, for example.

4.4.9 Apple’s Mobile Device Management Software

A strong consideration for using the Apple Server solution was the unified software suite which accompanies the system. Part of this solution is called Mobile Device Management (MDM) and its accompanying interface Profile Manager.

Profile Manager is designed to send out system preferences to an entire network from the server. Through a convenient web interface a change can be made on the server which will affect all of the machines connected to the network that have downloaded what Apple refers to as the MDM profile. This profile contains a server certificate and a handshake credential, which allows each machine to check in periodically with the server and download any updates to the System Preferences that do not align with the current settings in the MDM. Profile manager was in use in Computer Music but was disabled prior to the start of the academic year. While
the theoretical advantages to the MDM software are apparent (easier administrator access to preference panes, standardized access levels for users to system preferences, and a standardized model that could quickly be installed on all machines), it had to be removed after multiple failures. These failures were traced to incompatibilities with certain aspects of the Johns Hopkins Enterprise, and resulted in the following issues:

1. Client machines disconnecting from the LDAP database
2. Removal of all security protocols from the machines after a system update
3. Loss of internet connection
4. Most seriously, an intermittent loss of connection to the MDM, resulting in the computers going into a “security lockdown” type mode, preventing administrative access to critical system components

Because so much time was devoted to solving these issues and significant system downtimes were experienced, it was decided to not use the MDM system until such time it was more compatible with the Johns Hopkins Enterprise.

4.4.10 Securing the Client Machines

Removal of the MDM software and profiles did not eliminate the need to secure the client machines. It was necessary to strike a balance between allowing users the
access they need to critical functionalities without compromising the need for network security. Certain services had to be disabled in that interest. WiFi cards in each networked computer were disabled for concern of creating so-called bridge networks. This was initially met with some criticism as certain objects in Max/MSP, such as Lemur or c74 rely on WiFi for connecting the mobile device with the host computer, however, it was necessary for compliance with Enterprise Security Restrictions.

4.4.11 MatLab

MatLab 2014 was installed on all department machines to further enable graduate research into sound analysis and synthesis. MatLab is a coding language used by mathematicians and engineers to run high-level algorithms and renderings of mathematical functions. MatLab can interface with existing computer music languages to send these algorithms to them. This software was provided to us by Johns Hopkins University at no charge to the department.

4.5 Web Presence

Updating the OS X server required a simultaneous upgrade to the department’s web presence. The upgrade increased ease of editing and the ability to dynamically update content on the website and have it archived automatically by a content manager system. Additionally, social media integration was needed for marketing,
a collaborative learning environment were needed for certain classes, and a need for online scheduling of departmental resources and a ticketing system for scheduled maintenance was needed. These were all made possible by the LDAP database.

### 4.5.1 WordPress

WordPress is an open-source “personal publishing system built on PHP and MySQL”.\(^{10}\) It is open-source and allows for a user to easily update web content in real time. WordPress was chosen by the department for three reasons: ease of use, its integration with OpenLDAP, and its open source and expandable nature. In the past, the PCM website served as a bridge to the outside world. . The department still has a need to maintain a website for educational purposes, interactions with our sister studios, and for multimedia distribution and storage.

A content management system with a relational database backend was identified by myself and Dr. Wright as the solution for this need. Because of the now ubiquitous nature of WordPress, it was chosen as the most likely solution that a graduate-level system administrator would already know.

WordPress features WYSIWYG (what-you-see-is-what-you-get) editors similar in look and feel to desktop publishing applications, which allow users to edit articles without an advanced knowledge of PHP. Additionally, WordPress’ integration with LDAP allows all PCM users to make (moderated) postings to the website. This was

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CHAPTER 4. THE UPGRADE OF THE PEABODY COMPUTER MUSIC STUDIOS TO ENHANCE WORKFLOW AND USER EXPERIENCE

4.5.2 The OS X Wiki

Separate from the WordPress blog, the OS X Wiki system is a second and important part of the PCM web system. A wiki is a website that allows any registered user to build content collaboratively. Built in to the OS X Enterprise Server package, the Wiki allows any user with valid LDAP credentials to log in and post things in various wikis. Users can create wikis, delete their own wikis and comment on other wikis. By sorting users into groups based on their registered classes, as discussed above, classes can have their own shared wiki space which can be restricted from outside viewing.

The single greatest benefit to the wiki is that because it is web based software, it
Figure 4.3: The PCM Wiki Homepage

can be accessed on or off campus without the VPN. LDAP credentials are sent securely across the internet using SSL (secure socket layer) encryption and forwarded to the LDAP directory for authentication. The wiki system also features a WYSIWYG editor, allowing students to edit pages without an extensive knowledge of MediaWiki markup. Because the wiki is editable by everyone, the wiki also contains studio documentation and PDF formatted manuals for all synthesizers and software owned by the Computer Music Department. Because the WordPress site relies on certain access levels to edit postings, it was decided that it was unfeasible to store studio documentation in that location.
CHAPTER 4. THE UPGRADE OF THE PEABODY COMPUTER MUSIC STUDIOS TO ENHANCE WORKFLOW AND USER EXPERIENCE

4.5.3 User Webpages

After much consideration it was decided to keep user websites active. Each departmental user has the privilege of uploading a website to the server and have it face the outside world. As websites become increasingly needed for musicians in today’s digital age, and multimedia web page design is part of PCM curriculum, it is important to keep that functionality available to our users.

4.5.4 Booked

Booked, an open-source resource scheduling system, was implemented to allow users to reserve studio space and resources. Booked integrates with the LDAP directory to allow users to schedule rooms and devices, and most importantly, see all changes throughout the entire department in real time. This system is currently in use at the Milton S. Eisenhower Library at the Johns Hopkins University with excellent results. Booked is now successfully in use in PCM’s studios.

4.6 Changes at the Studio Level

In addition to the large-scale changes made at the departmental level, small changes were made at the studio level to ensure that each studio, for each of its different purposes, operates at its peak efficiency. These changes were local and primarily affected the studios themselves. Across all studios, a number of open source
CHAPTER 4. THE UPGRADE OF THE PEABODY COMPUTER MUSIC STUDIOS TO ENHANCE WORKFLOW AND USER EXPERIENCE

Software packages were installed to assist in learning, as well as complete installation of all licensed Digital Audio Workstations on all machines.

4.6.1 Digital Arts Studio (307)

The purpose of the digital arts studio is to provide a collaborative learning environment equipped with several machines and a large working space for hardware and computer graphics experimentation. The only major change in this space was the purchase of a new iMac which replaced a broken machine. This brought the department’s working terminal count in the space to three. The ethernet jacks in the space were also equipped with cables to allow students to access the networking resources, especially the iTunes media server, from their personal machines.

4.6.2 Digital Performance Studio (309)

The studio is equipped with the department’s Yamaha disklavier, a 4.1 channel sound system and a laptop computer. The computer is portable for use in concert performances. Two major changes were made to this studio to increase usability during the academic year. The laptop computer software was rebuilt completely, which increased its speed and stability. Additionally, the department purchased a new Allen and Heath Q16 digital mixer. This mixer was chosen because it doubles as a 12 channel audio interface for the computer and because its multi-user functionality
and networking capabilities allow it to be controlled wirelessly and save different user changes through an easy to use touch-screen graphical interface. It is also used as the department’s primary portable concert production mixer.

4.6.3 Production Studio (312)

Though a significant amount of software was updated for ongoing compatibility, no major hardware changes were made in this studio.

4.6.4 Teaching Studio (314)

The Teaching Studio is also equipped with a 4.1 channel sound system, a Mac Pro tower, two analog Moog synthesizers, and various rack-mounted synthesizers. Though a significant amount of software was updated for ongoing compatibility, no major hardware changes were made in this studio. A small point of interest however had to do with the setup of the computer for LDAP purposes in both 312 and 314. These computers have separate hard drives for user home folders and for the software. On a non-networked computer system it is relatively easy to change the location of the /Users directory. However, because changing this setting in the Open Directory would affect all machines in the department, and since not all departmental machines are equipped with this feature another solution had to be found. A symbolic link was created between /Users and /Volumes/User_Hard_Drive and solved this problem.
CHAPTER 4. THE UPGRADE OF THE PEABODY COMPUTER MUSIC STUDIOS TO ENHANCE WORKFLOW AND USER EXPERIENCE

4.7 PCM: The Next Steps

Over the past year, the Peabody Computer Music department has implemented a number of changes to become a fully digital, bring-your-own-device environment. These changes open the department to new possibilities: real-time international collaborations, long-term compatibility with future technologies, and a new way to route sound through the department. These changes are both technological and cultural, and are intended to have a long-lasting impact on the Peabody Computer Music department.

4.7.1 Technological Shifts

The installation of a gigabit network in the department is an accomplishment to be proud of, and is one that aligns the department for future improvements. This technology must be utilized to future-proof the studios. This can be accomplished through the use of a sound over IP protocol such as Dante.\footnote{11. Audinate, Inc., “Dante Overview,” https://www.audinate.com/solutions/dante-overview.}

Dante is a sound over IP protocol which allows up to 64 channels per IP address of uncompressed audio to be streamed across a gigabit network in real-time.\footnote{12. Ibid.} Since the protocol is implemented in hardware only, it eliminates the need for expensive software licensing. While there are hardware requirements, this system will solve several issues pertaining to the interface that the PCM musicians will have with their

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12. Ibid.
CHAPTER 4. THE UPGRADE OF THE PEABODY COMPUTER MUSIC STUDIOS TO ENHANCE WORKFLOW AND USER EXPERIENCE

departmental studios. Firstly, it will free the instruments from the confines of the studios themselves. Secondly, it will eliminate the long, noisy cable runs currently interconnecting two of the four studios within the department. Finally, it will enable all students to access the audio interfaces through ethernet, allowing them to freely work on their own machines. Therefore, by integrating Dante into the studios it will no longer be necessary for the department to support as many computer systems. The department could instead support two fully-loaded Mac Pro machines and encourage the students to use their own machines in tandem with these for mixing and mastering tracks.

Theoretically, a Dante installation would allow any computer connected to any ethernet port within the Computer Music department to receive and send audio to and from any machine (synthesizer, sound board, instrument, etc.) that was connected, either directly to the network or indirectly through a break-out box and process it directly on their own machine. It would allow sound to be patched in real time without a loss of signal to any room in the department. This or similar protocols are a logical extension of the gigabit network. As Dante or similar protocols appear to be an important aspect of future studio environments, it seems only necessary that graduate students in a major conservatory should have exposure and access to these important technological developments.
CHAPTER 4. THE UPGRADE OF THE PEABODY COMPUTER MUSIC STUDIOS TO ENHANCE WORKFLOW AND USER EXPERIENCE

4.7.2 Cultural Shift – Bring Your Own Device

A shift in thinking in the department is in progress. Now that computing technology has become both affordable and portable, most students in the department now have their own personal computers. The nature of the studios therefore, is about to change. Rather than providing terminals with a selected amount of software, it is now possible to remove many terminals from the studios and provide the ability to interlink with the departments sound systems through Dante. The next step for the department therefore is what will go into a studio that is specifically geared towards the “bring your own device” mentality, and what that studio will possibly look like to accommodate that goal.

4.8 Conclusion

The changes made during the summer of 2014 and throughout the 2014-2015 school year were significant and challenging. They required extensive collaborations with Peabody Information Technology as well as Johns Hopkins Information Technology at the Mount Washington campus. Multiple service calls to Apple Computer had to be made, several changes in thinking had to occur, and a much work still is to be done. However, the result is a product to be proud of. The new unified system is not only an important teaching tool, but an integral part of the graduate curriculum, intended to teach students how to manage their own studio systems. From the user
CHAPTER 4. THE UPGRADE OF THE PEABODY COMPUTER MUSIC STUDIOS TO ENHANCE WORKFLOW AND USER EXPERIENCE

perspective, the system is fully unified. The credentials that the user is issued to log into the Computer Music network allow the user to schedule studio time, request equipment, host a website, participate in collaborative learning, and many other capabilities. These requirements would not be found in a standard studio installation and are unique to the educational environment. Regardless, the changes that have been made in the Computer Music department have created the most unified and well-designed system that the department has had. The department is now positioned for a new era of cutting-edge digital technology that has the student user in mind.
Bibliography


BIBLIOGRAPHY


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——. “MAC Address: a unique hardware address.” http://www.linfo.org/mac%5C_address.html.


BIBLIOGRAPHY


