Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

The AudioGraph Web-based Lecturing System

A dissertation presented in partial

Fulfilment of the requirements for the degree of

Doctor of Philosophy

In

Computer Science

At Massey University, Palmerston North,

New Zealand.

Horia Cristian Slusanschi

2004

Abstract

In recent years, the pace of technological development has grown tremendously. As a result, the half-life of knowledge has decreased from hundreds and tens of years to just a few years or even mere months in certain fields. In order to be able to adapt efficiently to this unprecedented wave of knowledge, organizations and individuals must adopt new ways of learning and training.

Web-based education is a viable solution to the problem of quickly disseminating fresh knowledge as it emerges. However, one of the main challenges of effective web-based education remains the application of sound educational principles in the design and delivery of technology-enabled courses.

Our primary aim has been to provide lecturers with an effective and easy to use system that would assist web-based teaching and learning, allowing them to focus on the application of relevant educational principles rather than requiring them to master arcane technical complexities.

To enhance our perspective and better inform our design decisions, we explore the factors contributing to effective web-based education and examine a number of existing lecturing systems applicable to the development and distribution of educational content over the Web.

We then investigate means of preparing and presenting educational content. We place particular emphasis on the guiding principles of human interface design that have permeated our work, and have contributed to the enhanced usability characteristics of our system. We then discuss the challenges of data compression and review the technologies we chose to help make our approach viable and efficient.

In describing the software architecture of the system, we introduce the various design patterns that have helped our successful implementation gain robustness and flexibility, and discuss various tradeoffs encountered throughout the design and development of the system.

Finally, we present the conceptual and technical conclusions we have reached and we briefly explore future avenues of research and indicate a number of particularly interesting and potentially fruitful areas.

Acknowledgements

I would like to acknowledge a number of people without which this endeavour would not have been possible.

A special thank you must go to Professor Chris Jesshope, my supervisor, for all the trust he has put in my efforts, and especially for making it all possible. I would also like to extend my deepest gratitude towards Dr. Eva Heinrich for her relentless excellent suggestions and gracious guidance of my later work of improving the presentation of this research with invaluable advice.

I would like to thank the many people at Massey University, which I have met in the past few years, whose names are too many to mention here, and who have already put a substantial amount of effort into using and further developing the AudioGraph system, for their tireless persistence and innumerable excellent suggestions.

Most importantly, I would like to thank my wife, Anca, for her constant encouragement and enduring patience throughout the duration of this work.

Table of Contents

Abstract iii

Acknowledgements v

Table of Contents vii

Table of Figures x

1 Introduction 1

1.1 Motivating Forces 1
1.2 Web-based Education 4
1.3 The AudioGraph Idea 13
1.3.1 Vision 13
1.3.2 Intended Users 16
1.3.3 Starting Context 16
1.3.4 Analysis 20
1.4 Research Objectives 21
1.5 Methodology and Structure of the Thesis 22

2 Existing Lecturing Systems 25

2.1 Educational Systems Taxonomies 25
2.2 Authoring Approaches for Online Lectures 26
2.2.1 Multimedia Content Authoring 27
2.2.2 Web-based Course Authoring 28
2.2.3 Customised, Interactive Course Authoring 29
2.3 Evaluation Criteria 34
2.4 Multimedia Authoring Systems 35
2.4.1 PowerPoint 35
2.4.2 Impatica 36
2.4.3 HyperCard 37
2.4.4 Assessment 38
2.5 Authoring Capabilities of Web-based Authoring Systems 40
2.5.1 WebCT 40
2.5.2 TopClass 41
2.5.3 Blackboard 42
2.5.4 Mentorware 43
2.5.5 Assessment 44
2.6 Authoring Capabilities of Web-based Course Management Systems 45
2.6.1 ToolBook 45
2.6.2 Authorware 49
2.6.3 Quest 54
2.6.4 Assessment 57
2.7 Summary 58

3 The AudioGraph Web-based Lecturing System 61

3.1 Use of the AudioGraph System in Lecturing 61
3.2 Requirements Analysis 62
3.2.1 Requirements Derived from the Analysis of the AudioGraph Prototype 63
3.2.2 Requirements Derived from the Analysis of Existing Lecturing Systems 64
3.3 The AudioGraph Concepts 65
3.3.1 The AudioGraph Web-ready File Format 65
3.3.2 The AudioGraph Authoring and Playback Model 66
3.3.3 The AudioGraph Display Model 67
3.3.4 The AudioGraph Annotations 68
3.4 Evolution of the AudioGraph System Components 75
3.5 The AudioGraph Recorder 76
3.5.1 Lecture Documents 76
3.5.2 Episodes 78
3.5.3 Preferences 86
3.6 The AudioGraph Players 90
3.7 Summary 92

4 Software Engineering Context 95
4.1 Human Interface Design 95
4.1.1 Human Interface Design Principles 97
4.1.2 Managing Complexity 107
4.1.3 Future Design Decisions 108
4.2 Data Compression 109
4.2.1 Image Compression 110
4.2.2 The Challenges of Speech Compression 119
4.3 Design Patterns 125
4.3.1 Introduction to Design Patterns 126
4.3.2 Terms 127
4.3.3 Composite 127
4.3.4 Iterator 128
4.3.5 Memento 129
4.3.6 Template Method 130
4.3.7 Strategy 130
4.3.8 Builder 132
4.3.9 Singleton 133
4.3.10 Decorator 134
4.3.11 Command 135
4.3.12 Observer 136
4.4 Development Frameworks 137
4.5 Summary 138
5 Software Architecture 141
5.1 Mission 142
5.2 Architectural Representation 142
5.3 Architectural Goals and Constraints 142
5.3.1 PowerPlant Framework 143
5.3.2 QuickTime Technology 144
5.4 Recorder Architecture 145
5.4.1 Use-Case View 145
5.4.2 Logical View 146
5.4.3 Deployment View 169
5.4.4 Performance 169
5.5 Browser Plug-in Architecture 171
5.5.1 Use-Case View 171
5.5.2 Logical View 172
5.5.3 Deployment View 176
5.5.4 Performance 176
5.6 Player Architecture 178
5.6.1 Logical View 178
5.6.2 Deployment View 179
5.7 Design Patterns Applied 179
5.7.1 Composite — Usage Examples 179
5.7.2 Iterator — Usage Examples 181
5.7.3 Memento — Usage Examples 185
5.7.4 Template Method — Usage Examples 185
5.7.5 Strategy — Usage Examples 187
5.7.6 Builder — Usage Examples 189
5.7.7 Singleton — Usage Examples 190
5.7.8 Decorator — Usage Examples 190
5.7.9 Command — Usage Examples 191
5.7.10 Observer — Usage Examples 191
5.7.11 Other Useful Techniques 192
5.8 Summary 193
6 Conclusions 195
6.1 Evaluation of the AudioGraph System 195
6.2 Conceptual Aspects 196
6.3 Technical Aspects 199
6.4 Advantages of an Iterative Software Engineering Methodology 202
6.5 Summary 203

7 Future Work 205

7.1 Evaluation and Iterative Improvement 205
7.2 Integration in Learning Management Systems 207
7.3 Alternative Distribution Formats 208
7.3.1 Synchronised Multimedia Integration Language (SMIL) 209
7.3.2 Flash 210
7.3.3 QuickTime 212
7.3.4 MPEG-4 213
7.4 Extended Media Support 215
7.5 Other Improvement Opportunities 217
7.6 Summary 218

Appendix A. The AudioGraph System in Action 221

Appendix B. QuickTime Technology 229

B.1 Atoms 229
B.2 Media Structures 229
B.3 Components 230
B.4 Time Management 230

Appendix C. The Emergence of XML and its Related Technologies 233

C.1 Extensible Markup Language (XML) 234
C.2 Scalable Vector Graphics (SVG) 240

Bibliography 241

AudioGraph-related Resources 241
Education Resources 243
Software Engineering Resources 250
Data Compression Resources 256
General Resources 260

Table of Figures

FIGURE 1.1 FACTORS CONTRIBUTING TO EFFECTIVE WEB-BASED EDUCATION 6
FIGURE 1.2 LEARNING STYLES ACCORDING TO KOLB [32] (PP. 79) 9
FIGURE 1.3 FIRST PRINCIPLES OF INSTRUCTION 11
FIGURE 1.4 INSTRUCTIONAL APPLICATION DESIGN ARCHITECTURE 12
FIGURE 1.5 THE AUDIOGRAPH PROTOTYPE [1] RECORDER AND PLUG-IN 17
FIGURE 1.6. STUDENTS' PERCEPTIONS (IN PERCENTAGES) OF USING THE WEB-BASED LECTURES CONTRASTED WITH ATTENDING CONVENTIONAL LECTURES (25 UNDERGRADUATES AND 9 POSTGRADUATES) 18
FIGURE 3.1. THE AUDIOGRAPH DISPLAY MODEL 67
FIGURE 3.2. ROUND LINE DRAWING EXAMPLES. 68
FIGURE 3.3. SHARP LINE DRAWING EXAMPLES 69
FIGURE 3.4 AUDIOGRAPH SYSTEM EVOLUTION 75
FIGURE 3.5. TYPICAL LECTURE WINDOW FOR VERSION 1.0 OF THE AUDIOGRAPH RECORDER 77
FIGURE 3.6. THUMBNAILS VIEW FOR VERSION 1.0 OF THE AUDIOGRAPH RECORDER 77
FIGURE 3.7. EPISODE WINDOW CONTROLS 78
FIGURE 3.8. THE TOOLS PALETTE AND ITS CONTROLS FOR VERSION 1.0 OF THE AUDIOGRAPH RECORDER 79
FIGURE 3.9. THE EDIT CONSOLE IN VERSION 1.0 OF THE AUDIOGRAPH RECORDER 81
FIGURE 3.10. ANNOTATIONS WITH SPECIAL ATTRIBUTES 82
FIGURE 3.11. THE CONTROLS IN THE EDIT CONSOLE FOR VERSION 1.0 OF THE AUDIOGRAPH RECORDER 83
FIGURE 3.12. THE ATTRIBUTES PALETTE IN VERSION 1.0 OF THE AUDIOGRAPH RECORDER, IN ITS TWO STATES 85
FIGURE 3.13. THE SOUND IN PREFERENCES PANEL 86
FIGURE 3.14. GRAPHICS PREFERENCES PANEL 88
FIGURE 3.15. EDITING PREFERENCES PANEL 89
FIGURE 3.16. GENERAL PREFERENCES PANEL 90
FIGURE 3.17. BROWSER PLUG-IN EXAMPLE 91
FIGURE 3.18. LOAD PROGRESS INDICATOR IN THE BROWSER PLUG-IN PROGRESS BAR. 92
FIGURE 3.19. CONTROL FEATURES IN THE PRESENCE OF LINKED PRESENTATIONS 92
FIGURE 3.20. CONTROL FEATURES FOR SMALL-SIZE PRESENTATIONS 92
FIGURE 4.1. LOCKING A LECTURE PREVENTS UNWANTED CHANGES 98
FIGURE 4.2. THE COMMANDS IN THE EDIT MENU REFLECT THE CURRENT EXECUTION CONTEXT 99
FIGURE 4.3. VARIOUS FORMS OF FEEDBACK ARE AVAILABLE WHEN SAVING A LECTURE 99
FIGURE 4.4. DYNAMIC FEEDBACK DURING SOUND RECORDING 103
FIGURE 4.5. LOSSY COMPRESSION MAY INTRODUCE ARTEFACTS IN TEXTUAL MONOCHROME IMAGES 112
FIGURE 4.6. ANTI-ALIASED TEXT EXAMPLE. 116
FIGURE 4.7. OVERVIEW OF THE RPE-LTP COMPRESSION SCHEME 123
FIGURE 5.1 CONCEPTUAL MODEL OF ARCHITECTURAL DESCRIPTION (IEEE 1471) 141
FIGURE 5.2 RECORDER HIGH-LEVEL USE CASE DIAGRAM 145
FIGURE 5.3. RECORDER APPLICATION CLASS DIAGRAM 146
FIGURE 5.4. LECTURE DOCUMENT CLASS DIAGRAM 149
FIGURE 5.5. EPISODE CLASS DIAGRAM 150
FIGURE 5.6. LECTURE WINDOW CLASS DIAGRAM 153
FIGURE 5.7. EPISODE WINDOW CLASS DIAGRAM 154
FIGURE 5.8. HOST VIEW CLASS DIAGRAM 155
FIGURE 5.9. TOOLS PALETTE WINDOW CLASS DIAGRAM 156
FIGURE 5.10. EDIT CONSOLE WINDOW CLASS DIAGRAM 158
FIGURE 5.11. ATTRIBUTES WINDOW CLASS DIAGRAM 160
FIGURE 5.12. PREFERENCES WINDOW CLASS DIAGRAM 162
FIGURE 5.13. VISUAL COMPONENT CLASS HIERARCHY 164
FIGURE 5.14. AUDIO COMPONENTS CLASS HIERARCHY 165
FIGURE 5.15. CLASS HIERARCHY FOR THE OTHER ANNOTATION COMPONENTS 166
FIGURE 5.16. FILE BUILDING CLASS DIAGRAM 167
FIGURE 5.17 AUDIOGRAPH DEPLOYMENT DIAGRAM 169
FIGURE 5.18 BROWSER PLUG-IN AND PLAYER USE-CASE DIAGRAM 171
FIGURE 5.19. CLASS DIAGRAM FOR VERSION 1.0 OF THE BROWSER PLUG-IN 172
FIGURE 5.20. CLASS DIAGRAM FOR VERSION 2.0 OF THE BROWSER PLUG-IN 174
FIGURE 5.21. CLASS DIAGRAM FOR THE STAND-ALONE MACINTOSH AUDIOGRAPH PLAYER 178
FIGURE 5.22. AUDIOGRAPH RECORDER COMPONENT CLASS HIERARCHY 180
FIGURE 5.23. POWERPLANT CORE VISUAL ELEMENTS CLASS HIERARCHY 180
FIGURE 7.1.THE EXTENSIBLE MPEG-4 TEXTUAL FORMAT 214
FIGURE A.1. EXPORTING A MICROSOFT POWERPOINT PRESENTATION AS A MACINTOSH SCRAPBOOK FILE 221

FIGURE A.2. OPENING A SCRAPBOOK FILE IN THE AUDIOGRAPH RECORDER 221
FIGURE A.3. A FRESHLY IMPORTED SCRAPBOOK FILE 222
FIGURE A.4. RENAMING EPISODES 222
FIGURE A.5. THUMBNAILS VIEW 223
FIGURE A.6. SAVING THE LECTURE 223
FIGURE A.7. ADDING ANNOTATIONS 224
FIGURE A.8. EDITING ALL EPISODES 224
FIGURE A.9. EXPORTING IN COMPACT PRESENTATION FORMAT 225
FIGURE A.10. THE FILES GENERATED IN THE COMPACT EXPORT FORMAT 225
FIGURE A.11. THE AUDIOGRAPH COMPACT PRESENTATION VIEWED IN THE PLUG-IN 226
FIGURE A.12. EXPORTING A LECTURE IN EXPANDED FORMAT 227
FIGURE A.13. THE EXPANDED FORMAT WEBSITE 227
FIGURE A.14. THE EXPANDED LECTURE INDEX 228

Massey University
COLLEGE OF SCIENCES

Institute of Information Sciences & Technology
Private Bag 11 222,
Palmerston North,
New Zealand
Telephone: 64 6 350 5799
Facsimile: 64 6 350 5723

Integrated Research and Teaching in the Fields of:

Statistics & Applied Statistics

Computer Science & Information Systems

Information & Electronic Engineering

Candidate's Declaration

This is to certify that the research carried out for my Doctoral Thesis entitled "The AudioGraph Web-based Lecturing System" in the Institute of Information Sciences and Technology, Massey University, Palmerston North Campus, New Zealand is my own work and that the thesis material has not been used in part or in whole for any other qualification.

Candidate's Name: Horia Cristian Slusanschi

Signature:

Date: 09/02/2004

Te Kunenga ki Pūrehuroa
Inception to Infinity: Massey University's commitment to learning as a life-long journey

Massey University
COLLEGE OF SCIENCES

Institute of Information Sciences & Technology
Private Bag 11 222,
Palmerston North,
New Zealand
Telephone: 64 6 350 5799
Facsimile: 64 6 350 5723

Integrated Research and Teaching in the Fields of:

Statistics & Applied Statistics

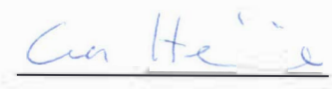
Computer Science & Information Systems

Information & Electronic Engineering

Supervisor's Declaration

This is to certify that the research carried out for the Doctoral Thesis entitled "The AudioGraph Web-based Lecturing System" was done by Horia Cristian Slusanschi in the Institute of Information Sciences and Technology, Massey University, Palmerston North Campus, New Zealand. The thesis material has not been used in part or in whole for any other qualification, and I confirm that the candidate has pursued the course of study in accordance with the requirements of the Massey University regulations.

Supervisor's Name: Dr. Eva Heinrich

Signature: 

Date: 04/02/2004

Massey University
COLLEGE OF SCIENCES

Institute of Information Sciences & Technology
Private Bag 11 222,
Palmerston North,
New Zealand
Telephone: 64 6 350 5799
Facsimile: 64 6 350 5723

Integrated Research and Teaching in the Fields of:

Statistics & Applied Statistics

Computer Science & Information Systems

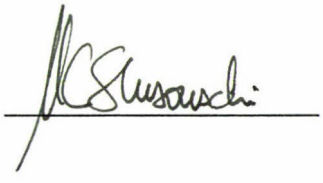
Information & Electronic Engineering

Certificate of Regulatory Compliance

This is to certify that the research carried out in the Doctoral Thesis entitled "The AudioGraph Web-based Lecturing System" in the Institute of Information Sciences and Technology, Massey University, Palmerston North Campus, New Zealand:

- Is the original work of the candidate, except as indicated by appropriate attribution in the text and/or in the acknowledgements;
- That the text, excluding appendices/annexes, does not exceed 100,000 words;
- All the ethical requirements applicable to this study have been complied with as required by Massey University and relevant legislation.

Candidate's Name: Horia Cristian Slusanschi Supervisor's Name: Dr. Eva Heinrich

Signature:  Signature:

Date: 09/02/2004 Date: 04/02/2004