Web Based Timetable Scheduling System For Applied Sciences At The College Of Arts And Sciences (CAS)

Sari Mahmoud Ali Al-zou'bi

UNIVERSITI UTARA MALAYSIA

2008

Web Based Timetable Scheduling System For Applied Sciences At The College Of Arts And Sciences (CAS)

A thesis submitted to the Graduate School in partial fulfillment of the requirements for the degree Master of Science (Information and Communication Technology)
Universiti Utara Malaysia

By

Sari Mahmoud Ali Al-zou'bi (89296)

KOLEJ SASTERA DAN SAINS
(College of Arts and Sciences)
Universiti Utara Malaysia

PERAKUAN KERJA KERTAS PROJEK
(Certificate of Project Paper)

Saya, yang bertandatangan, memperakukan bahawa
(I, the undersigned, certify that)

SARI MAHMOUD ALI AL-ZOU'BI

calon untuk Ijazah
(candidate for the degree of) **MSc. (ICT)**

telah mengemukakan kertas projek yang bertajuk
(has presented his/her project paper of the following title)

WEB-BASED TIMETABLE SCHEDULING SYSTEM FOR APPLIED SCIENCES AT THE COLLEGE OF ARTS AND SCIENCES (CAS)

seperti yang tercatat di muka surat tajuk dan kulit kertas projek
(as it appears on the title page and front cover of project paper)

bahawa kertas projek tersebut boleh diterima dari segi bentuk serta kandungan dan meliputi bidang ilmu dengan memuaskan.
(that the project paper acceptable in form and content, and that a satisfactory knowledge of the field is covered by the project paper).

Nama Penyelia Utama
(Name of Main Supervisor): **ASSOC. PROF. DR. WAN ROZAINI SHEIK OSMAN**

Tandatangan
(Signature) : Rozaini

Tarikh
(Date) : 25/5/08

PERMISSION TO USE

In presenting this thesis in partial fulfillment of the requirements for a postgraduate degree from Universiti Utara Malaysia, I agree that the University Library may make it freely available for inspection. I further agree that permission for copying of this thesis in any manner, in whole or in part, for scholarly purpose may be granted by my supervisor(s) or, in their absence by the Dean of Faculty of Information Technology. It is understood that any copying or publication or use of this thesis or parts thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and to Universiti Utara Malaysia for any scholarly use which may be made of any material from my thesis.

Requests for permission to copy or to make other use of materials in this thesis, in whole or in part, should be addressed to

Dean of Faculty of Information Technology

Universiti Utara Malaysia

06010 UUM Sintok

Kedah Darul Aman.

ABSTRACT

Timetabling is a problem that concerns every teaching institution. Every year a new timetable must be produced to take account of staff, student and course changes causing a necessarily large amount of work. CAS faces a considerable amount of difficulties especially before the start of academic semesters due to the increased number of students and courses. The main objective of this study is to develop a web-based application for timetable scheduling for the CAS. Implementing this prototype in CAS will return in many benefits for both the CAS staff and the students. However some work and studies still need to be done to this system as described in the recommendations section.

Acknowledgements

I would like to say thank you to every one who had supported me to finish my work.. First, I would like to thank Assoc. Prof. Dr. Wan Rozaini bt Sheik Osman for her advice and supervision during the preparation of this project; thank you to my evaluator Mr.Azmi Md Saman for his suggestions and help.

Furthermore I would like to thank my friend Abu Issa, Qusi, Ashraf, Muhammed, Malik, Ra'afat and Yuosof for their kindness and support, I am grateful to all lecturers at Applied Science College Of Art And Science formally faculty of Information Technology, because they guidance to support along the way.

Above all, I would like to thank my Mother and Father and my sisters Mona and Reem and my brother Muhammad and Sadam and brothers-in-law Hassan and Mofaq and my niece Rama and Jana and all my family members for their encouragement and support during the period of my studies especially my fiancee -to – be, N.

Above all, I would like to thank my best friends Amer, Raed, Ali, Abu Obidallah, Abu Qasim, Abu Yuosof, Abu Hussin, Alkadi, Abu Kazal, Waael, Aiman, and Hashim for their encouragement

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Introduction

As demand for education increases and diversifies, so does the difficulty of designing workable timetables for schools and academic institutions. Besides the intractability of the basic problem, there is an increasing variety of constraints that come into play (Rahoual and Saad, 2003).

Typical web-based systems consist of a database, a database query language and various components such as scripts and web servers that work together in a multi-tiered fashion. These systems can have massive amounts of confidential and trusted information, with quite complex security policies. Developing Web-based systems is significantly different from traditional software development and poses many additional challenges. There are subtle differences in the nature and life cycle of web-based and software systems and the way in which they are developed and maintained. Web development is a mixture between print publishing and software development, between marketing and computing, between internal communications and external relations, and between art and technology (Powell, 1998).

The contents of the thesis is for internal user only

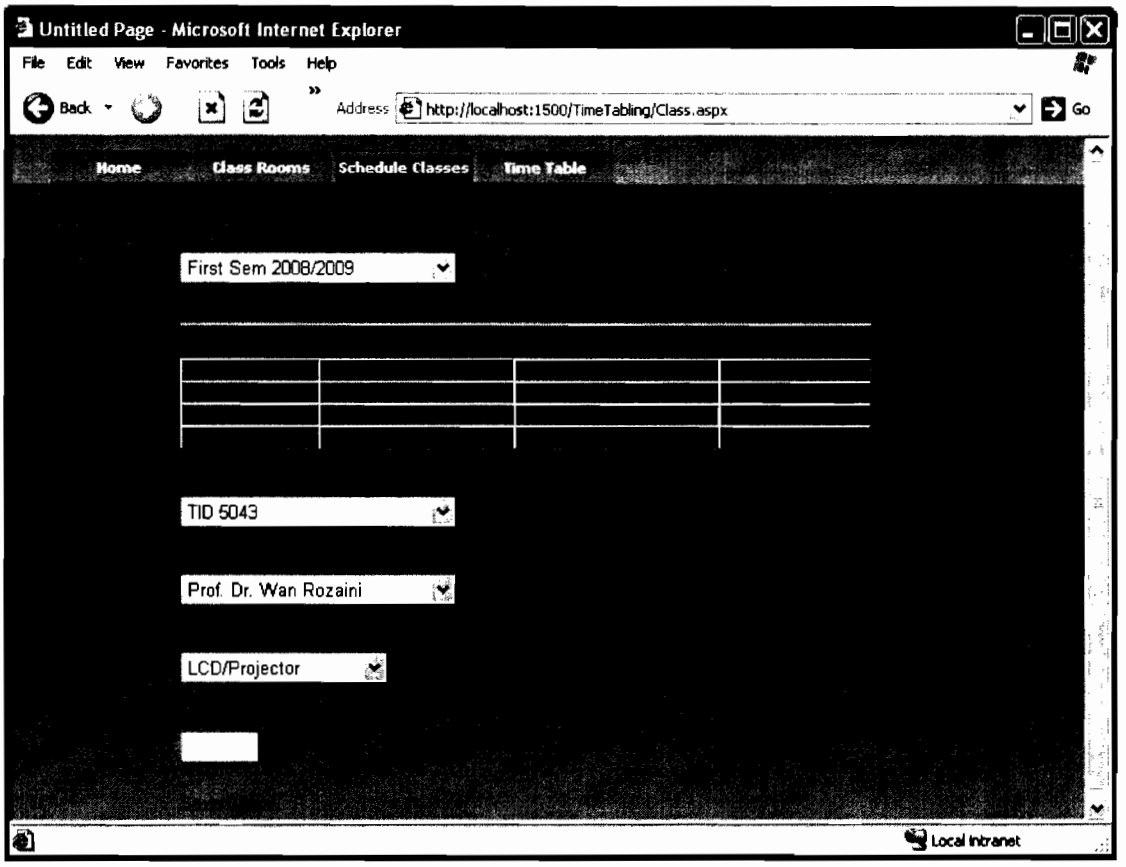

Figure 4.12: Schedule Class Page

This page allow the user to add new class to the list of classes in the semester, the user has to enter all related information in the page and then click save to add the new class to the database as in Figure 4.12.

4.5.3 Class Rooms Page

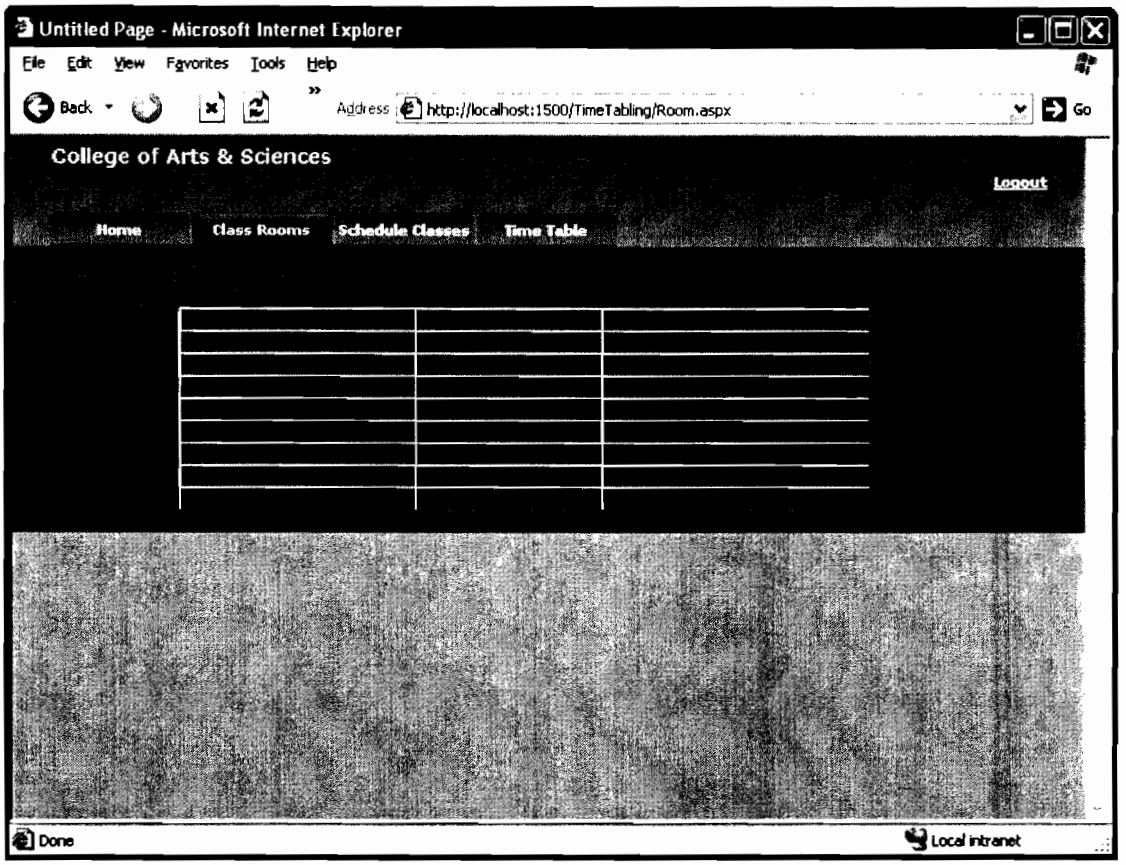

Figure 4.13: Class Rooms Page

This page is used by the college administration to view all Rooms Entered in the system showing the room specification and type, the user can add more rooms to the system and can enter all details about the capacity of the room or the type of the room, the user can save his entries to the system as in Figure 4.13.

4.5.4 Time Table Page

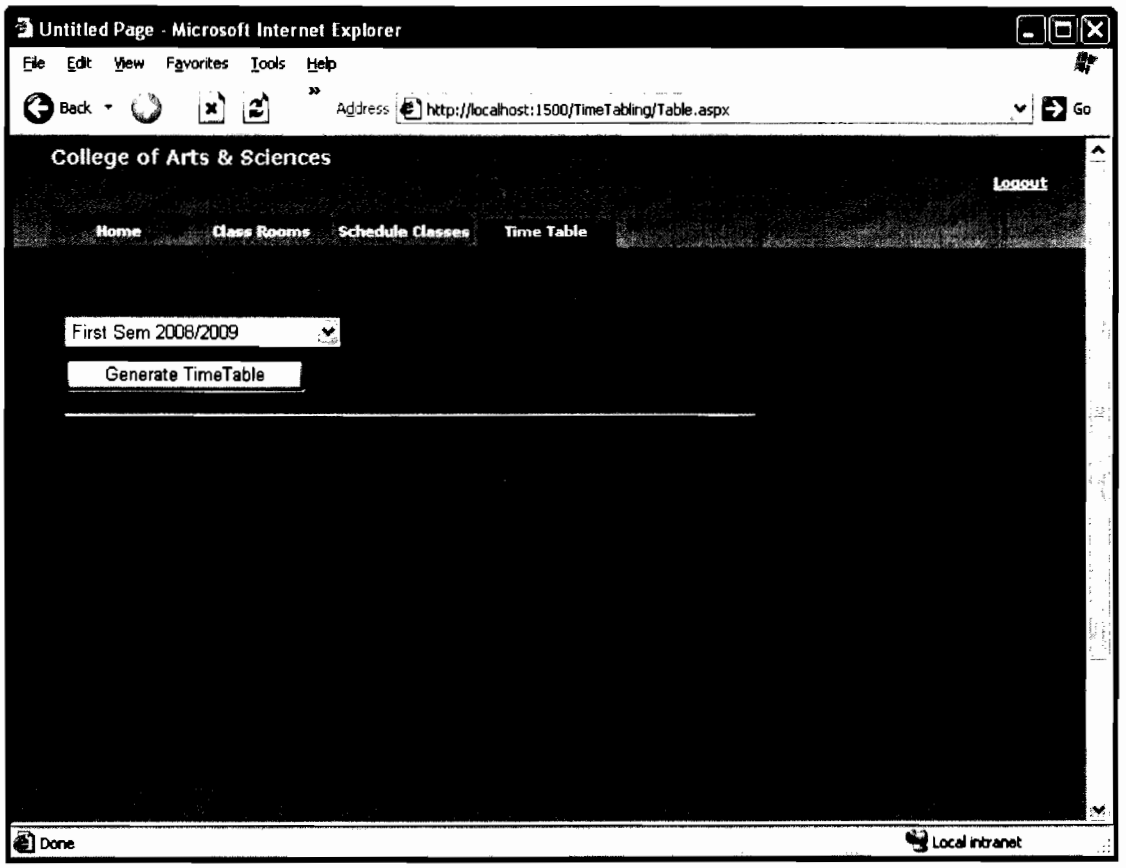

Figure 4.14: Time Table Page

This page is used by the college administration to generate the time table by choosing the semester and clicking the generate time table button the system will automatically generate the time table and display it to the user , the user can finally save the time table to the database as in Figure 4.14.

4.6 Timetabling System Database Design

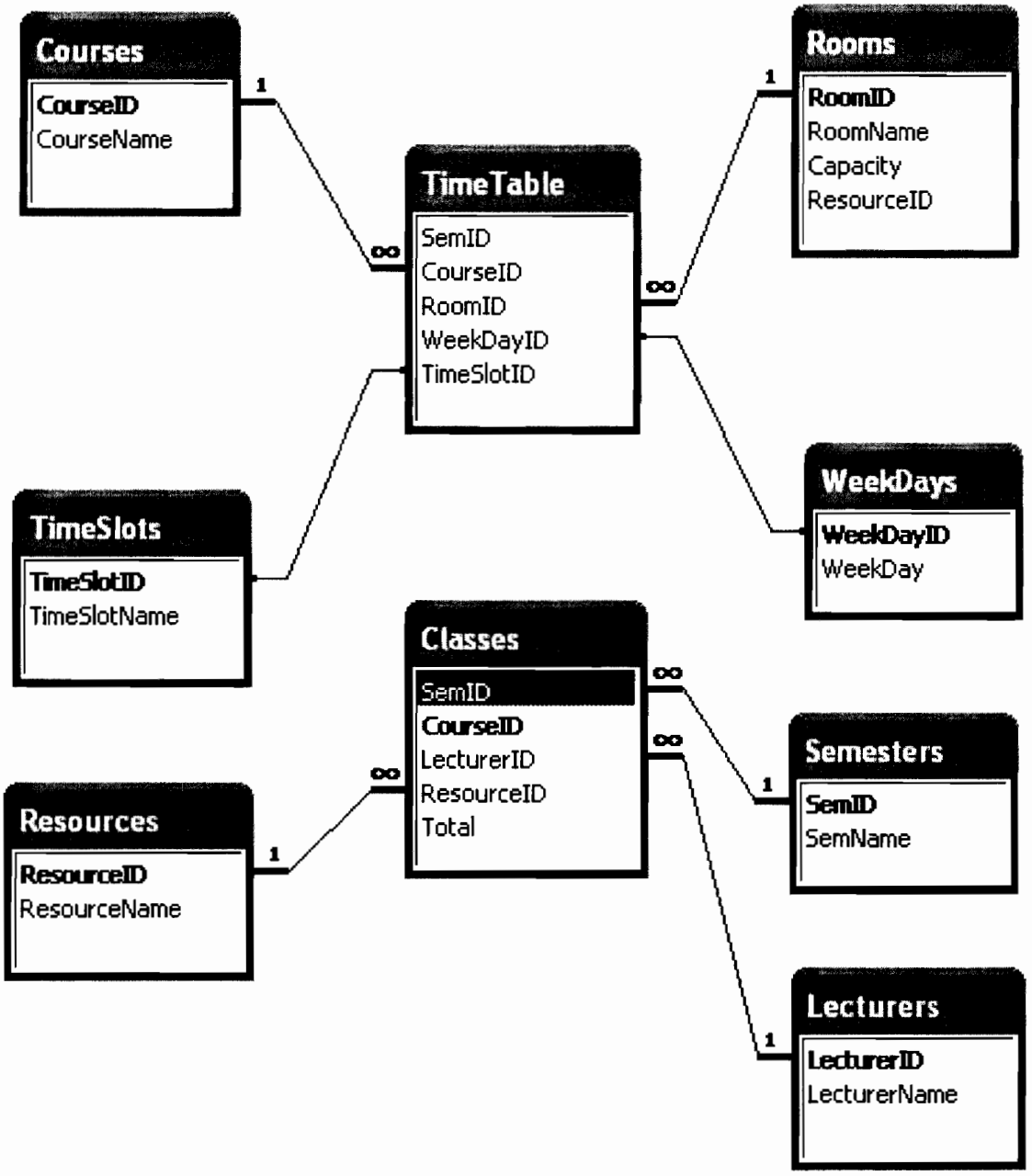

Figure 4.15: Timetabling Database Schema

The database schema shown in Figure is the Timetabling database for storing the class information, room specifications, and the distribution of rooms across the classes as in Figure 4.15.

The database schema shown in Figure reflects the actual hierarchy of the entities in the systems database. The main entities in the schema are the Timetable, Classes, and Rooms, the other tables are used mainly for lookup and login purposes

4.7 Summary

Using the computer-based and web Timetabling system will allow for better interaction between different departments in the college of arts and sciences , graphical representation of data enables both the academic staff and other staff to access the same information about the allocation of class rooms in the college in a seamless way and elevating a lot of efforts from the communication process between the involved parties, and allow the college administration to focus on giving the right distribution of rooms rather than looking after other details.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1. Introduction

The conclusion chapter presents a review of the study's whole design and development activities included. This includes problems and limitations encountered during the development of this project. Finally, this chapter will be ended with possible directions for future work related to the project.

5.2. Conclusion

A web-based timetabling prototype was developed for College of Arts and Sciences of UUM in order to save time and effort for CAS staff in producing classes time tables every new semester and to make that difficult task easier and push up it performance since this task incorporating many variables to deal with and it usually faces many conflicts in time or locations of the classes.

Implementing this prototype in CAS will return in many benefits for both the CAS staff management and academicians in one part and the students in the other part since they will have no problems during courses registration regarding time conflict or classes' capacity and other usual registration problems they face each semester. In addition the managerial staff will not face the usual problems of preparing the timetables for each semester and will stop receiving students complains about courses registration.

However some work and studies still need to be done to this system as described in the recommendations section in order to make the system reliable, up to date and converting the timetabling and classes scheduling process to a fully automated process by the system and to ensure the consistency of the data across all UUM related departments' databases.

5.3. Problems and Limitations

This study has achieved its proposed objectives of building a web-based system for CAS timetabling. However, some problems and limitations revealed during and earlier to the development of the model as follow:

- This study handled the timetabling problem of CAS by generating the classes' timetable based on two variants only which are the class rooms' requirements of each class and based on the time line so it makes sure that no time or room conflict between the classes.

- The solution of this study is not dealing with the lecturers' allocation for courses since it takes it as requirement for generating the time tables. So in order to generate the time table the lecturers of the courses must be provided manually.
- The prototype's database is built using Microsoft Office Access 2003 so it may encounter some limitations during the deployment and real testing such as the security issues and the performance which not appear during the development.
- The prototype's database is a stand alone one and is not integrated with the UUM databases like the postgraduate school database and registration department that are already exist and this requires ensuring about the data consistency when storing or retrieving any data or performing any registration transaction.

5.4. Recommendations

Throughout the design and development of this prototype, several issues about its design and development were exposed. Future design and development in the same field of this study should take in their considerations the following recommendations and guidelines:

- This prototype should be developed farther to include in its variables list the lecturers' timetables so building the classes schedule or timetable should be based on four variables which are the rooms availability at all the classes timeslots, the resources required by each class must be available in the room booked for it, the classes timetable should has no time conflict between the

classes and last building the timetable must take in consideration the timetable of each lecturer and his availability time to give the lecture or not.

- Another important development can be done to this prototype is to integrate it with an expert system for allocating the lecturers to the courses based on their qualifications, area of specialization and their experience in teaching the course. After this integration the system will be full automated and the CAS managerial stuff needs to do nothing but get the timetable ready for publishing.
- Another important consideration for future development and projects is to integrate this prototype database with the related university databases such as the Registration department and the postgraduate school to ensure the consistency of the data stored and retrieved from the system database and to make sure it's always up to date and to make the system more reliable.

References

Abdennadher S., Marte, M. (2000) University course timetabling using constraint handling rules. Journal of Applied Arti_cial Intelligence, 14(4):311.

Abramson, D. (1992). "Constructing School Timetables using Simulated Annealing: Sequential and Parallel Algorithms," *Management Science*, vol. 37, pp. 98-113.

Aggoun, A. & Beldiceanu, N. (1993). "Extending CHIP in Order to Solve Complex Scheduling and Placement Problems," Mathematical and Computer Modelling 17, 57-73.

Baptiste, Ph. & Le Pape, C. (1995). "A Theoretical and Experimental Comparison of Constraint Propagation Techniques for Disjunctive Scheduling," Proceedings 14th International Joint Conference on Artificial Intelligence, 600-606, Morgan Kaufmann.

Bennett, S., McRobb, S., & Farmer, R. (2002). Object-Oriented Systems Analysis and Design Using UML, Second Edition, McGraw Hill Education.

Bistarelli, S., Montanari, U., and Rossi, F. (1997). Semiring-based constraint solving and optimization. Journal of ACM, 44(2):201.

Bloomfield, S., and McSharry, M. (1979). "Preferential Course Scheduling," *Interfaces*, vol.9, no. 4, pp. 24-31, The Institute of Management Sciences. School of Business, Oregon State University, Corvallis, USA

Boizumault, P., Delon, Y., and Peridy, L. (1996). "Logic Programming for Examination Timetabling," *Logic Program.*, vol. 26, pp. 217-233.

Brelaz, D. (1979)"New methods to color the vertices of a graph," *Commun. ACM*, vol. 22, pp. 251-256.

Burke, E. K., Eckersley, A. J., McCollum, B., Petrovic, S., and Qu., R. (2004). "Analysing similarity in examination timetabling," in E. K. Burke and M. Trick, *Proceedings of the 5th International Conference on the Practice and Theory of Automated Timetabling.*, pp. 557-559.

Burke, E., Jackson, K., Kingston, J., Weare, R. (1997), Automated University Timetabling: The State of the Art, The Computer Journal, Vol. 40, No. 9.

Burke, E., Elliman, D., Weare, R. (2000): Automated Scheduling Of University Exams, Dept. of Computer Science, University of Nottingham.

Burke, E.K., Newall, J.P.(2004): Solving examination timetabling problems through adaptation of heuristic orderings. Annals of Operations Research, 129, 107-134.

Burke, E., Elliman, D., and Weare, R. (1994). "The Automation of the Timetabling Process in Higher Education," *Journal of Education Technology Systems*, vol. 23, pp. 257- 266.

Burke, E. K., and Newall, J. P. (1998). "A Multi-Stage Evolutionary Algorithm for the Timetable Problem," *IEEE Transactions on Evolutionary Computation*, vol. 3, pp.63-74.

Burke, E. K. and Trick, M. A. (2005). *Practice and Theory of Automated Timetabling V, 5th International Conference, PATAT 2004*, vol. 3616 of Lecture Notes in Computer Science. Springer Verlag, Berlin, Germany

Burke, E. K. and Carter, M. W. (1998). *Practice and Theory of Automated Timetabling II, Second International Conference, PATAT 1997*, vol. 1408 of Lecture Notes in Computer Science. Springer Verlag, Berlin, Germany.

Burke, E. K. and de Causmaecker, P. (2003).*Practice and Theory of Automated Timetabling IV, 4th International Conference, PATAT 2002*, vol. 2740 of Lecture Notes in Computer Science. Springer Verlag, Berlin, Germany.

Burke, E. K. and Petrovic, S. (2002)."Recent research directions in automated timetabling," *European Journal of Operational Research*, **140**(2), 266-280.

Burke, E. K. and Erben, W. (2001)., *Practice and Theory of Automated Timetabling III, Third International Conference, PATAT 2000*, vol. 2079 of Lecture Notes in Computer Science. Springer Verlag, Berlin, Germany

Chahal, N., Werra, D. (1989), An Interactive System for Constructing Timetables on a PC, European Journal of Operational Research, Vol. 40, Issue 1.

Colorni, A., Dorigo, M., Maniezzo, V. (1998), Metaheuristics for High School Timetabling, Computational Optimization and Applications, Vol. 9, No. 3, 1998.

Caseau, Y. & Laburthe, F. (1994). "Improved CLP Scheduling with Task Intervals," Proceedings 11th International Conference on Logic Programming, MIT Press.

Caseau, Y. & Laburthe, F. (1995). "Disjunctive Scheduling with Task Intervals," Technical Report, Ecole Normale Supérieure.

Carter, M. (1986a). "A Survey of Practical Applications of Examination Timetabling Algorithms," *Operations Research*, vol. 34, pp. 193-202.

Carter, M. (1986b)."A Langarian Relaxation Approach to the Classroom Assignment Problem," INFOR, vol. 27, pp. 230-246.

Carter, M., Laporte, G., and Chinneck, J. (1994). "A General Examination Scheduling System," Interfaces, vol. 24, no. 3, pp. 109-120, The Institute of Management Sciences.

Carter, M., Laporte, G., and Lee, S. Y. (1996). "Examination Timetabling: Algorithmic Strategies and Applications," Journal of the Operational Research Society, vol. 47, pp.373-383.

Carter, M., and Laporte, G. (1998). Resent developments in practical course timetabling In Edmund Burke and Michael Carter, editors, Practice and Theory of Automated Timetabling II, pages 3{19. Springer-Verlag LNCS 1408.

Carter M.W., (2001). A Comprehensive Course Timetabling and Student Scheduling System at the University of Waterloo, E. Burke, W. Erben (Eds.): Proceedings of PATAT 2000, Springer-Verlag.

Carter, M. and Laporte, G. (1996). "Recent Developments in Practical Examination Timetabling," in *Practice and Theory of Automated Timetabling (PATAT) I*, vol.1153, E. Burke and P. Ross, Eds. Berlin: Springer-Verlag, pp. 3-21.

Chand, A., (2004). "A constraint based generic model for representing complete university timetabling data," in E. K.Burke and M. A. Trick (eds.), *Proceedings of the 5th International Conference on the Practice and Theory of Automated Timetabling.* pp. 125-150.

Colombani, Y. (1996). "Constraint Programming: An Efficient and Practical Approach to Solving the Job-Shop Problem," Proceedings 2nd International Conference on Principles and Practice of Constraint Programming, 149-163, Springer-Verlag.

Cooper, T., and Kingston, J. (1996). "The Complexity of Timetable Construction Problems," in *the Practice and Theory of Automated Timetabling*, ed. EK Burke and P Ross, pp. 283-295, Springer-Verlag (Lecture Notes in Computer Science). Basser Department of Computer Science, University of Sydney, Australia

Colorni A., Dorigo M., Maniezzo V., (1990). Genetic Algorithms and Highly Constrained Problems: the Time-Table Case, Proceedings of the First International Workshop on Parallel Problem Solving from Nature, Lecture Notes in Computer Science 496.

Corne, D., Ross, P., and Fang, H. (1994). "Evolving Timetables," in *The Practical Handbook of Genetic Algorithms*, vol. 1, L. C. Chambers, Ed.: CRC Press, pp. 219-276.

Custers, N. P. De Causmaecker, P. Demeester, and G. V. Berghe (2005)."Semantic components for timetabling," in E. K. Burke and M. A. Trick (eds.), *Practice and Theory of Automated Timetabling, Springer Lecture Notes in Computer Science Volume 3616*, pp. 17-33.

Daskalaki, S., Birbas, T., and Housos, E. (2004). "An integer programming formulation for a case study in university timetabling," *European Journal of Operational Research*, vol.153, pp. 117-135.

Deris, B., Omatu, S., Ohta, H., and Samat, D. (1997)."University Timetabling by Constraintbased Reasoning: A Case Study," *Journal of Operational Reasearch Society*, vol. 48, pp. 1178-1190.

Deris, B., Omatu, S., Ohta, H., and Samat, D. (1999). "University Timetabling by Constraint-based Reasoning: A Case Study," Journal of Operational Reasearch Society, vol. 48, pp. 1178-1190.

Dong Pan (1998). The Application of Design Patterns in Knowledge Inference Engine. Unpublished Master Thesis. The University of Calgary. Calgary, Alberta.

DeWerra. D., (1985). "An introduction to timetabling," *European Journal of Operational Research*, **19**(2), 151-162.

Di Gaspero, L. and A. Schaerf, (2002). "Writing local search algorithms using EASYLOCAL++,Ó in S. Vo§ and D.L. Woodruff, (eds.), *Optimization Software Class Libraries*, pp. 81Ð154. Kluwer Academic Publishers, Boston,MA, USA.

Do M.B., Kambhampati S., (2001). Planning as constraint satisfaction: Solving the planning graph by compiling it into CSP, Artificial Intelligence 132.

Erben, E. (2000). "A Grouping Genetic Algorithm for Graph Colouring and Exam Timetabling," in Practice and Theory of Automated Timetabling (PATAT) III, vol. 2079, Lecture Notes in Computer Science, E. Burke and W. Erben, Eds. Berlin: Springer-Verlag, pp. 132-158.

Fang, R.(2005), University Course Scheduling System (UCSS) —A UML Application with Database And Visual Programming, Arkansas Tech University

Filho, G., and Lorena, L.(2001). A Constructive Evolutionary Approach to School Timetabling. Applications of Evolutionary Computing EvoWorkshops.

Fink, A. and S. Vo§, (2002). "A heuristic optimization framework," in S. Vo§ and D.L. Woodruff (eds.), Optimization Software Class Libraries, pp. 81Ð154. Kluwer Academic Publishers, Boston, MA, USA.

Foulds, L.R., Johnson, D.G. (2000). SlotManager: a microcomputer-based decision support system for university timetabling, Decision Support Systems 27.

Freuder E., and Wallace, R. (1992). Partial constraint satisfaction. Artificial Intelligence, 58:21{70.

Fruhwirth, T. (1995). Constraint handling rules. In Andreas Podelski, editor, Constraint Programming: Basics and Trends, LNCS 910. Springer.

Geller, S. (2006): Timetabling at the University of Sheffield, UK - an incremental approach to timetable development.

Goltz, H., Kuchler, G. and Matzke, D. (1998). Constraint-based timetabling for universities. In Proceedings INAP'98, 11th International Conference on Applications of Prolog, pages 75(80).

Gueret, C., Jussien, N., Boizumault, P., and Prins, C. (1996). Building university Timetables using constraint logic programming. In Edmund Burke and Peter Ross, editors, Practice and Theory of Automated Timetabling, pages 130{145. Springer-Verlag LNCS 1153.

Henz, M., and Wurtz, J. (1996). Using Oz for college timetabling. In Edmund Burke and Peter Ross, editors, Practice and Theory of Automated Timetabling, pages 162{177. Springer-Verlag LNCS 1153.

Hentenryck, P. (1989). Constraint Satisfaction in Logic Programming. MIT Press.

Jaffar, J., and Maher, M. (1994). Constraint logic programming: A survey. Journal of Logic Programming, 19:503{581, 1994.

Kothari, C. R. (1985). Research Methodology, Methods and Techniques. Delhi: Wiley Eastern Limited.

Lajos, G. (1996)."Complete University Modular Timetabling using Constraint Logic Programming," in *Practice and Theory of Automated Timetabling (PATAT) I*, vol.1153, *Lecture Notes in Computer Science*, E. Burke and P. Ross, Eds. Berlin: Springer-Verlag, pp. 146-161.

McCollum B., (1998). The Implementation of a Central Timetabling System in a Large British Civic University, E. Burke, M. Carter (Eds.): Proceedings of PATAT 1997, Springer-Verlag.

Myszkowski P., Norberciak M., (2003). Evolutionary Algorithms for Timetable Problems, Annales UMCS, Sectio Informatica, vol. I, Lublin Newall J. P., (1999). Hybrid Methods for Automated Timetabling, PhD Thesis, Department of Computer Science, University of Nottingham.

Norberciak M., (2004). Artificial Intelligence Technique for Planning Duties in Hospital , Journal of Medical Informatics & Technologies, Vol. 7.

Nuijten, W. P. M. (1994). "Time and Resource Constrained Scheduling: A Constraint Satisfaction Approach," PhD Thesis, Eindhoven University of Technology, Eindhoven, The Netherlands.

Nuijten, W. P. M. & Aarts, E. H. L. (1996). "A Computational Study of Constraint Satisfaction for Multiple-Capacitated Job-Shop Scheduling," European Journal of Operational Research 90, 269-284.

Ojha, P., Walker, A. (2000), A comparison of Course Scheduling Methods, Xavier University, OH, from http://www.cs.xu.edu/~lewandow/reu2000/paper/)

Petrovic, S., and Burke, E.K.(2004): University Timetabling. Handbook of Scheduling: Algorithms, Models, and Performance Analysis, Chapman and Hall Press.

Powell, T.A. (1998). Web Site Engineering: Beyond Web Page Design, Prentice Hall, Upper Saddle River, N.J.

Paechter, B., Rankin, R., Cumming, A. (1997). "Timetabling the Classes of an Entire University with an Evolutionary Algorithm," in Parallel Problem Solving from Nature (PPSN) V, vol. 1498, Lecture Notes in Computer Science, T. Baeck, A.Eiben, M. Schoenauer, and H. Schwefel, Eds. Berlin: Springer-Verlag, pp.865-874.

Post, G. and Veltman, B. (2004). "Harmonious personnel scheduling," in E. K. Burke and M. A. Trick (eds.), Proceedingsof the 5th International Conference on the Practice and Theory of Automated Timetabling. PATAT 2004, pp.557-559.

Romero, B.(1982). "Examination Scheduling in a Large Engineering School: A Computer-Assisted Participative Procedure," Interfaces, vol. 12, no. 2, pp. 17-23, The Institute of Management Sciences. Industrial Organization Department, Industrial Engineering Technical School, Madrid, Spain

Rahoual, M., Saad, R. (2003). Solving Timetabling Problems by Hybridizing Genetic Algorithms and Tabu Search, Université d'Evry Val d'Essonne

Ross P., Corne D., (1995). Comparing GA, SA and Stochastic Hillclimbing on Timetabling Problems. Evolutionary Computing; AISB Workshop,Sheffield 1995, Selected Papers, ed. T. Fogarty, Springer-Verlag Lecture Notes in Computer Science 993.

Ross P., Hart E., Corne D., (1998). Some Observations about GA-Based Exam Timetabling, E. Burke, M. Carter (Eds.): Proceedings of PATAT 1997, Springer-Verlag.

Schaerf, A. (1995). A survey of automated timetabling. Technical Report CS-R9567, CWI, Amsterdam, NL.

Schaerf, A., (1999)."A survey of automated timetabling," Artificial Intelligence Review, 13(2), 87-127.

Socha K., Knowles J., Sampels M., (2002). A MAX-MIN Ant System for the University Course Timetabling Problem, Proceedings of ANTS 2002, Springer-Verlag.

Tam, V., Ting, D. (2003), Combining the Min-Conflicts and Look-Forward Heuristics to Effectively Solve a Set of Hard University Timetabling Problems, Proceedings of the 15th IEEE International Conference on Tools with Artificial Intelligence.

Tripathy, A. (1984)."School Timetabling - A Case in Large Binary Linear Integer Programming " Managment Science, vol. 30, pp. 1473-1489.

Vaishnavi, V., and Kuechler, B. (2004). Design Research in information system. Retrieved JAN 15, 2008, from http://www.isworld.org/Researchdesign/drisISworld.htm

Valouxis C., Housos E., (2000). Hybrid optimization techniques for the workshift and rest assignment of nursing personnel, Artificial Intelligence in Medicine 20.

White, G., and Chan, W. (1979). "Towards the Construction of Optimal Examination Schedules," INFOR, vol. 17, pp. 219-229.

Wren, A., (1996). "Scheduling, timetabling and rosteringÑa special relationship?," In E. K. Burke and P. Ross (eds.),Practice and Theory of Automated Timetabling, Springer Lecture Notes in Computer Science Volume 1153, pp. 46-75.

Yakhno T., Tekin E. (2002). Application of Constraint Hierarchy to Timetabling Problems, Proceedings of EurAsia-ICT 002, Springer- Verlag.

Yoshikawa, M., Kaneko, K., Yamanouchi, T., Watanabe, M.(1996), A Constraint-Based High School Scheduling System, IEEE Intelligent Systems, Vol. 11, No. 1.

Yellen J., Gross, J.L.(2003): Handbook of Graph Theory, Chapman Hall, CRC Press., 445-474.