

## **CMP 3060M - Project Assignment One – Project Proposal**

### **Cricket scheduling using optimisation algorithms**

#### **Introduction**

Many factors can affect the scheduling of cricket fixtures such as how many times teams play, availability of pitches, and if teams should play away or at home. Through this project a program should be created to find schedule solutions that can satisfy these factors. This is a problem that can be found in tournaments for many sports and there are many research papers on scheduling in other sports. The factors specific to this project will be laid out in detail by the client whilst gathering requirements for the project. On top of these factors the program should be able to account for individual team requirements such as needing to play away on certain dates or not being able to play at all on certain dates.

In many sports, fixtures are done in a single round-robin, where each team plays every other team exactly once, or double round-robin, where each team plays every other team once at home and once away. In a single round-robin tournament, the search space for all possible solutions can be calculated by  $n!$  where  $n$  represents the number of teams. Similarly, in a double round-robin tournament, the search space can be represented by  $(n!)^2$  if the rounds are separated or  $(2n)!$  if the rounds are mixed. The difficult part of this problem is to find a solution in this search space that will be able to fit all of the extra conditions that will be given by the client and each individual team.

Although it is easy to see that there is a large search space of solutions for scheduling without factors, the problem becomes increasingly complex as more factors are added. If there are enough factors added the problem may become NP-complete. If this was the case, although a solution would be quick to verify, the solution would not be easy to calculate. With this in mind, a successful program may need to use optimisation or evolutionary algorithms to traverse the search space to find a perfect solution. There is also a possibility that with certain sets of factors a perfect solution may not exist so a program solving this problem should also not search through the entire search space.

An important part of this project will be to develop a user interface that can be used to input the data for the tournament. A good solution would be a website which would allow access anywhere and solutions would be calculated without installing software. Hosting the program on a server has the additional bonus of using large numbers of high frequency processing cores which would significantly decrease the time needed to process a solution. It will be important to think about parallelism when developing the software so that it will run as efficiently as possible on any hardware.

## **Aims and Objectives**

The ultimate aim of this project is to develop a program to schedule cricket fixtures faster. The best system will be able to take an input and then output the solution as a list of all fixtures sorted by date, and a list for each team which displays all games that they play in the season.

- Gather requirements from client

The first objective will be to gather requirements from the client and identify the most important requirements so that a more detailed list of tasks and testing criteria can be made. During this meeting it will be important to gain information about how the data should be ideally inputted and how the results should be presented as an output. Conditions that the solution must meet should also be gathered at this time so that then can be used for testing and selecting a solution within the evolutionary algorithm.

- Write evolutionary algorithm

The next objective will be to write an evolutionary algorithm that will try finding the best solution for a given input. This algorithm will generate solutions based upon how successful the previously generated solutions were. It will use the given requirements to rank how successful each generated solution would be. Using this method should create more successful solutions as more data is processed.

- Create user interface for input and output

This part of the project is important for the user to interact comfortably and quickly with the application. Data should be inputted by the user and then produce a file that can be read by the evolutionary algorithm. The output should be in the form of a set of files that can be saved by the user

- Evaluate solution

The first way to evaluate if the application can produce successful solutions is if the solutions comply with all conditions that are required by the client. Comparing the application's solutions with solutions given by other scheduling applications will also give good indications that the application is successful. Finally, discussions with the client about the software will create valuable feedback which could be used to develop the application further.

## **Literature**

**Kendall, G., Knust, S., Ribeiro, C.C. & Urrutia, S. 2010, "Scheduling in sports: An annotated bibliography", Computers & Operations Research, vol. 37, no. 1, pp. 1-19.**

This article explains the fundamentals of the problem of scheduling in sports very well by showing the formulas and methods that can represent a double round-robin tournament which is what is required for cricket. It then goes on to talk about how heuristic and metaheuristic functions can be used to help formulate schedules. The article is very helpful by pointing to many useful pieces of literature about the subject.

**Drexler, A. & Knust, S. 2007, "Sports league scheduling: Graph- and resource-based models", Omega, vol. 35, no. 5, pp. 465-471.**

This article analyses the graph based model first suggested by de Werra (1981) and also discusses whether the problem of scheduling in sports is or is not NP-complete. The article goes on to present a resource based model for solving the problem. This model allows more constraints to be formulated such as multiple teams sharing a ground.

**L. Barone, L. While, P. Hughes & P. Hingston 2006, "Fixture-scheduling for the Australian Football League using a Multi-Objective Evolutionary Algorithm", 2006 IEEE International Conference on Evolutionary Computation, pp. 954.**

This explains a multi-objective algorithm created to schedule fixtures for the AFL. This problem differs slightly from the cricket problem as there is exactly 16 teams playing in the tournament and in total they play 22 games rather than  $2(n-1)$  games in cricket, where  $n$  represents the number of teams. Their algorithm seemed to produce a good number of valid solutions after a significant number of generations. This large number of generations was due to the extra factors such as travel times and distances in order to keep the tournament as fair as possible.

**L. While & L. Barone 2007, "Super 14 Rugby Fixture Scheduling Using a Multi-Objective Evolutionary Algorithm", 2007 IEEE Symposium on Computational Intelligence in Scheduling, pp. 35.**

This talks about super 14 rugby which, like the AFL, has a set number of teams that play. The tournament follows a single round-robin format which means that each team plays every other team exactly once. This presents a multi-objective evolutionary algorithm which calculates fixtures while accounting for factors such as "competition fairness, amount of travel, availability and distribution of games."

**Lewis, R. & Thompson, J. 2011, "On the application of graph colouring techniques in round-robin sports scheduling", Computers & Operations Research, vol. 38, no. 1, pp. 190-204.**

This article discussed colouring graphical methods to solve scheduling problems. This article also talks about the processing times and success rates of these methods when solving both single round-robin and double round-robin problems. It also concludes that a backtracking algorithm produces the quickest solutions with the highest success rate and that an ant colony optimisation algorithm is better than a hill-climbing algorithm.

## Plan

	'16							'17																		
	Oct	Nov			Dec			Jan				Feb				Mar				Apr						
Task	31	07	14	21	28	05	12	19	26	02	09	16	23	30	06	13	20	27	06	13	20	27	03	10	17	24
Write report																										
Gather client requirements																										
Format input																										
Write algorithm																										
Design interface																										
Create user interface																										
Test product																										
Evaluate solutions																										
Review Report																										

The first step in this project will be to meet with the client and collect requirements for the project. The first step of development will be creating a format for the input data to take. Creating this format first will save time whilst developing the algorithm however this format will likely change throughout the project. The algorithm will be developed before the user interface for two reasons: it is the most important part of the program and should be prioritised if it takes longer than expected to develop, and the user interface should be designed with the final input format in mind.

The algorithm will take the most time to develop and will likely need multiple versions that test conditions differently. The algorithm will need to be tried with different weightings set to each condition as these weightings will likely affect the efficiency of the algorithm.

Before starting development on the user interface it will be important to create designs. These designs should ideally be discussed and approved by the client before starting development.

After developing the user interface the program should be tested. This could be done by hosting a server on a local network and then use the service to process

solutions to already solved scenarios. The program will be successful if it can produce the solution that already exists or can produce a solution as efficient or better than the current solution.

### **Risks**

<b>Risk</b>	<b>Likelihood</b>	<b>Impact</b>	<b>Risk Quotient</b>	<b>Contingency</b>
Client unavailable for meetings	0.5	7	3.5	Organise meetings early
Projects requires learning new language(s)	0.7	6	4.2	Allocate extra time to development sections
Program cannot create perfect solutions	0.8	8	6.4	Program should suggest the best solution if no perfect solution can be found
Program takes a long time to process solutions	0.8	3	2.4	
Time allocated to Algorithm development is not enough	0.4	9	3.6	Algorithm is most important part so time from UI development should be used
Certain inputs could result in impossible scenario	0.9	7	6.3	Program should show why the given input is impossible
Client wishes to change requirements	0.3	8	2.4	
Program requires high end servers to run efficiently	0.6	6	3.6	Client should be notified. Lower end hardware will be suitable for demonstration purposes.

Program uses open source or licensed code	0.9	4	3.6	Credit will be given to all resources used.
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## **References**

Drexl, A. & Knust, S. 2007, "Sports league scheduling: Graph- and resource-based models", Omega, vol. 35, no. 5, pp. 465-471.

Kendall, G., Knust, S., Ribeiro, C.C. & Urrutia, S. 2010, "Scheduling in sports: An annotated bibliography", Computers & Operations Research, vol. 37, no. 1, pp. 1-19.

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de Werra, D. 1981, "Scheduling in Sports", North-Holland Mathematics Studies, vol. 59, pp. 381-395.



## Ethical Approval Form: Library/Desk/Lab/Studio-based Research Projects

This form must be completed for each piece of research activity whether conducted by academic staff, research staff, graduate students or undergraduates. Applications by students must be endorsed by an academic member of staff acting as Principal Investigator/supervisor. The completed form must be sent to the designated Ethics Committee within the Faculty.

**Please complete all sections.** If a section is not applicable, write N/A.

<b>1 Name of Applicant</b>	Adam Linscott
<b>2 School or Department</b>	School of Computer Science
<b>3 Position in the University</b>	Undergraduate
<b>4 Role in relation to this research</b>	Principal Investigator
<b>5 Name(s) of collaborators/co-workers and their relationship to the project (e.g. supervisor, assistant etc.)</b>	<i>Name, and role in project:</i> 1. Grzegorz Cielniak - Supervisor 2. Kevin Jacques - Client 3. 4. 5.
<b>6 Brief statement of main Research Question or Project Title</b>	Cricket scheduling using optimisation algorithms
<b>7 Ethical checklist</b>	<p>Does the research involve living human participants, or human tissue? Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>  <i>If you answered "yes", submit form EA2 for Ethical Approval.</i></p> <p>Does the research involve living animals, or animal tissue? Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>  <i>If you answered "yes", submit form EA3 for Ethical Approval.</i></p> <p>Does the research involve confidential data, or data not in the public domain? Yes <input type="checkbox"/> No <input checked="" type="checkbox"/></p> <p>Does the project potentially put you or your collaborators at physical or psychological risk? Yes <input type="checkbox"/> No <input checked="" type="checkbox"/></p> <p>Could the topic or results of this research be seen as illegal, or attract legal action against the University from an outside agency? Yes <input type="checkbox"/> No <input checked="" type="checkbox"/></p> <p>Could the topic or results of this research attract unwelcome media attention, or affect the reputation or standing of the University? Yes <input type="checkbox"/> No <input checked="" type="checkbox"/></p> <p>Could the topic, results or conduct of this research be regarded as offensive, immoral or destructive by some reasonable people? Yes <input type="checkbox"/> No <input checked="" type="checkbox"/></p> <p>Does this research need to be undertaken under a relevant professional code of conduct? Yes <input type="checkbox"/> No <input checked="" type="checkbox"/></p> <p>Are there any potential conflicts of interest in conducting this research, including financial gain for the researchers, or for individuals or external organizations affiliated with the researchers? Yes <input type="checkbox"/> No <input checked="" type="checkbox"/></p> <p>Are there any factors inhibiting the application of the University's ethical guidelines, including those on proper treatment of data, research design and publication of results? Yes <input type="checkbox"/> No <input checked="" type="checkbox"/></p> <p>Does the research require the approval of any external body? Yes <input type="checkbox"/> No <input checked="" type="checkbox"/></p> <p><b><i>If the answer to all questions above is "No", you may complete section 8 to certify that there are no ethical issues, submit this form to the relevant Ethics Committee, and proceed with the research immediately. You accept professional responsibility for this decision, and if unsure should instead submit to the Committee.</i></b></p> <p><b><i>If the answer to any of the above questions is "Yes", complete the rest of the form, submit to the relevant Ethics Committee, and await approval before proceeding with the research. Answering "Yes" does not necessarily imply that the research is problematic, only the Ethics Committee needs to consider the research to ensure that it can proceed, and that the research design conforms to best practice.</i></b></p>



**8 Self certification of Ethical Review**

Having reviewed the ethical implications of this research, I certify that there are no issues requiring Ethical Approval. I certify that the research will be carried out in compliance with the University's ethical guidelines for library/desk/laboratory/studio-based research, with Health and Safety regulations, and with all other relevant University policies and procedures. If there are any changes to the research requiring ethical clearance, I shall apply for such clearance before continuing with the research.

Signed:



Principal Investigator

**Note.** This section must be endorsed by the member of academic staff responsible for the project. In the case of research by students, the supervising member of academic staff must sign. The signed form should then be submitted to the relevant Ethics Committee within the Faculty, and the research may proceed.

**9 Does the research comply with the University's key ethical principles for library/desk/lab/studio-based research ?**

Yes ☐No ☐

If "No", provide an ethical justification for your project and explain why you wish to continue with the research in breach of normal ethical principles:-

**10 If applicable, please state the relevant professional code(s) under which the research is being conducted and confirm compliance**

**11 Does this research require the approval of an external body ?**

Yes ☐No ☐

If "Yes", please state which body:-

**12 Has ethical approval already been obtained from that body ?**

Yes ☐ -Please append documentary evidence to this form.No ☐

If "No", please state why not:-

Please note that any such approvals must be obtained and documented before the project begins.

**13 If there are any other ethical issues, to which the attention of the approving committee should be drawn, please state them in this section, and explain how you have taken the issues into account, so that the research should be approved. Please consult the University's ethical guidelines for advice.**

Please also include here, or attach separately, a brief description of the research, to allow the approving committee to reach judgement.



**APPLICANT SIGNATURE**

I hereby request ethical approval for the research as described above.

I certify that I have read the University's ethical guidelines for library/desk/laboratory/studio-based research.



\_\_\_\_\_  
Applicant Signature

26/10/16

\_\_\_\_\_  
Date

\_\_\_\_\_  
Adam Linscott

**FOR COMPLETION BY THE DESIGNATED FACULTY AUTHORITY**

Please select ONE of A, B, C or D below:

☐ A. The Faculty gives ethical approval to this research.

☐ B. The Faculty gives conditional ethical approval to this research.

10 Please state the condition (inc.  
date by which condition must be  
satisfied if applicable)

☐ C. The Faculty cannot give ethical approval to this research but refers the application to the University Research Ethics Committee for higher level consideration.

11 Please state the reason

☐ D. The Faculty cannot give ethical approval to this research and recommends that the research should not proceed.

12 Please state the reason, bearing in  
mind the University's ethical  
framework, including the primary  
concern for Academic-Freedom.

Signature of Designated Faculty Authority for Research Ethics

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Date

## Key ethical guidelines for library/desk/laboratory/studio-based research

The University of Lincoln has drawn up the following key principles for researchers engaged in library/desk/laboratory/studio-based projects in order to promote high professional standards. They should be read alongside the University's Ethical Principles for Conducting Research with Humans and Other Animals, and operate as part of the University's Ethical Framework.

- *Non-falsification of data*: Researchers have an ethical obligation to refrain from tampering with data. Thus questionnaire responses, experimental observations and data analyses should not be fabricated, altered nor discarded. In addition, researchers have a responsibility to exercise reasonable care in processing data to ensure no errors affect the results.
- *Ethics of reporting research*: Researchers are obliged to give full and proper attribution of ideas: presenting the words, data or ideas of another person as your own without properly citing them amounts to plagiarism. This is not only misconduct but can also be an infringement of copyright, amounting to theft of intellectual property.
- *Ethics and research design*: Researchers should be open to a range of methods: failure to consider and evaluate alternative methods and tools for the collection of data may be regarded as too overtly biased. All appropriate steps should be taken to ensure that no samples are obtained from unethical sources e.g. illegal databases; unregistered suppliers of samples from humans or other animals.
- *Authorship credit*: Only those researchers who are significant contributors to a research project should be given authorship credit. A "significant contributor" might be described as a person playing a major role in conceptualising, analysing or writing the final document. Ideally, all those involved in the research project should decide upon the order of authorship. Usually, the first author is the one who has made the biggest contribution.
- *Conflict of interest*: Researchers should be aware of the potential influence of personal or commercial interests on their work and take all practical measures to ensure that information is presented without distortion.
- *The principle of beneficence*: Researchers are required to protect individuals by seeking to maximise anticipated benefits and minimise possible harms. It is therefore necessary to examine carefully the design of the study and its risks and benefits including, in some cases, identifying alternative ways of obtaining the benefits sought from the research. Research risks must always be justified by the expected benefits of research.
- *Professional codes*: Researchers should undertake research legally and in accordance with any relevant professional codes of conduct.
- *Personal information*: Researchers should anonymise information which relates to individuals when they have not obtained informed consent, unless there is a clear justification to the contrary. They should also be aware of the impact of wider public dissemination of their work and the impact this might have on any individual or group of individuals. If it is anticipated that it might cause distress, it is essential to demonstrate that the benefits outweigh this risk.