Bournemouth University

Faculty of Science and Technology

Department of Computing & Informatics

Submission Coursework Brief
Postgraduate

Unit: SEARCH AND OPTIMISATION (COMP7065)		
Unit Contact: Jiankang Zhang	**Credits:** 20	**Level:** 7

Assessment Title: Multiple-Objective Routing Path Optimisation	
Assessment Number: 1 **of** 1	
Assessment Type: Group	**Weighting:** 100%
Deadline: 17/01/2025 at 12:00 PM	**Submission Method:** Turnitin (+ large file submission box)

Quality Assessor (QA): Paul Whittington	**Other Marker(s):** Botao Fan

Can I use Generative AI tools?
Basic spelling and grammar correction tools are permitted.

The following originality requirements will apply to this assignment:

You are allowed to use any Generative AI or other AI powered tools, such as ChatGPT, for specific aspects as directed by the Unit Leader. Where any part of your assessment is sourced, or partially sourced from a generative AI tool, this requires a reference in the BU Harvard style.

Task:

This is a group assignment; each group consists of 4~5 members. The students should discuss and sign up for a group on Brightspace before 8/11/2024. The student who did not sign up for a group will be randomly allocated to a group that has fewer than four members.

Background

In this assignment, you will address a real-world problem of routing path optimisation for wireless sensor networks, as shown in Fig. 1. A back dot represents a wireless sensor (node). In order to monitor the environment of the New Forest, hundreds of wireless sensors were deployed. The wireless sensors can collect environmental information, such as temperature, humidity, pressure, etc. The collected data will be forwarded to data processing centres located at Beaulieu and Lyndhurst, which have a base station (BS) at each site. However, due to the limitation of the communication range of the wireless sensors, some of them may not be able to connect to the BS located at Beaulieu and Lyndhurst directly. The data can be forwarded to one of their neighbour wireless sensors and then another sensor, and finally access a base station (BS), as illustrated in Fig. 1. Thus, each wireless sensor needs to find an optimal data packet routing path to a BS given the objectives to be optimized.

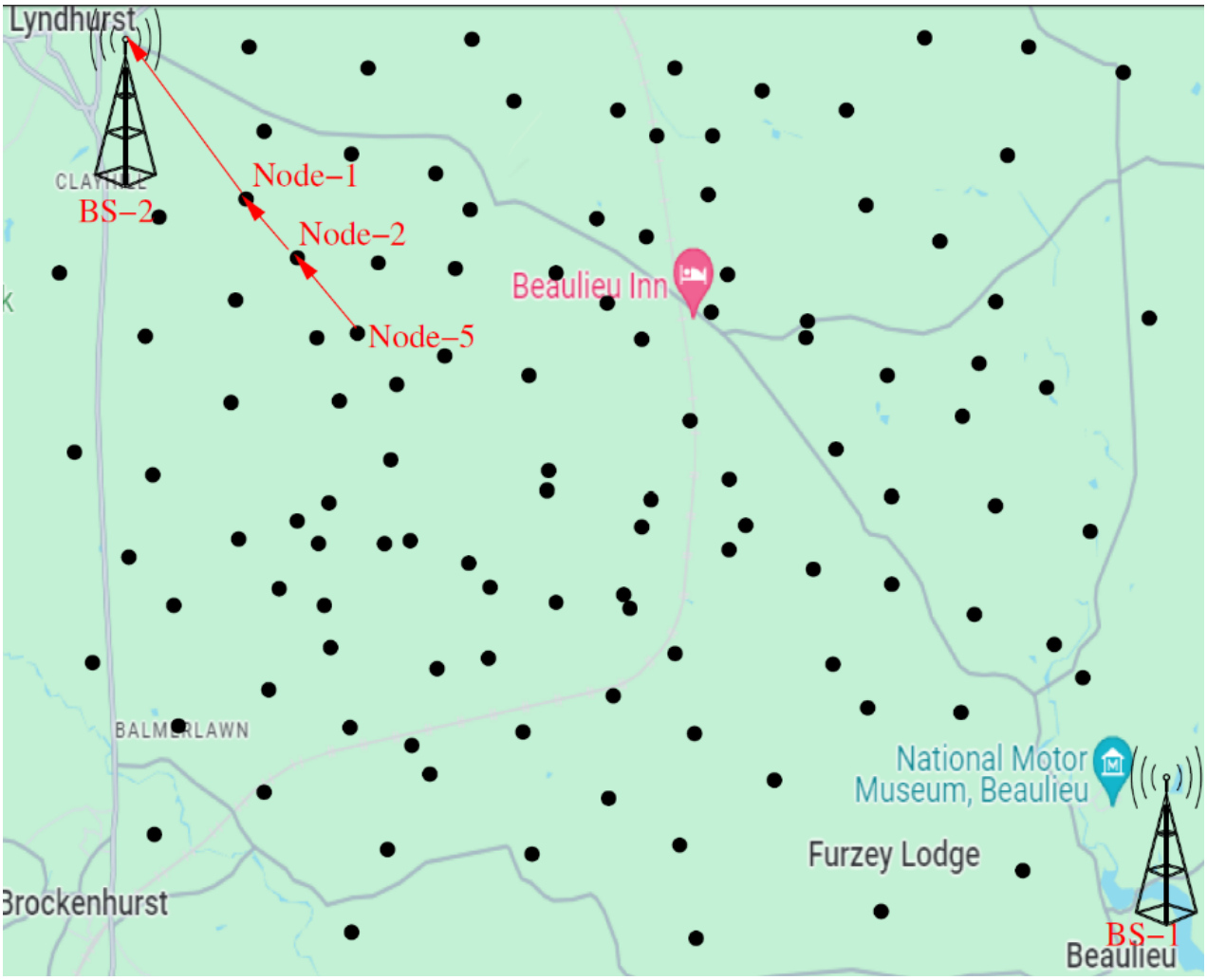

Fig.1 A toy example of finding the optimal routing path

There are two metrics to be considered, end-to-end data transmission rate and end-to-end latency to find an optimal data packet routing path. The end-to-end latency is the sum of all delays imposed by each link, whilst the end-to-end data transmission rate is defined as the minimum transmission rate of each link in the routing path. For example, a routing path is Node-5 ->Node-2 -> Node-1 -> BS-2

The delay imposed by each link is 30 milliseconds (ms). There are three links “Node-5 -> Node-2”, “Node-2 -> Node-1”, and “Node-1 -> BS-2”, so the end-to-end latency consists of three links, and the end-to-end latency will be 3 x 30 = 90 ms.

Let us use the same example of the routing path

Node-5 -> Node-2 -> Node-1 -> BS-2

to illustrate how to calculate the end-to-end data transmission rate. There are three links “Node-5 -> Node-2” with a transmission rate 1Mbs, “Node-2 -> Node-1” with a transmission rate of 4 Mbps, and “Node-1 ->B S-2” with a transmission rate of 2 Mbps. The end-to-end data transmission rate will be

Min{1 Mbps, 4 Mbps, 2 Mbps} = 1 Mbps

Furthermore, a link’s transmission rate is determined by the distance of a pair of communicating Nodes, which is given in Table 1. If the distance between a pair of Nodes is longer than 3000 m, there will be no connection between these two Nodes, so the transmission rate will be 0.

Distance *d*	Transmission rate (Mbps)
d >= 3000 m	0
3000 m > *d* >= 2500 m	1
2500 m > *d* >= 2000 m	2
2000 m > *d* >= 1500 m	3
1500 m > *d* >= 1000 m	4
1000 m > *d* >= 500 m	5
500 m > *d*	7

Optimisation problem

This is a multiple-objective optimisation problem. You should address this optimisation problem**using at least two optimisation algorithms**.

Find a routing path having the maximum end-to-end data transmission rate and minimum end-to-end latency for each node that can access any of a BS located at Beaulieu (5000,- 5000) or Lyndhurst (-5000,5000).

Requirements:

Your implementation should be in Python. You are allowed to use existing Python optimisation libraries or implementations if you need to, with references provided, but you should aim to implement as much as possible from scratch by yourself. Example codes from our lab seminars are also allowed to be reused with citations. If there is novelty/contribution of the optimisation algorithm, for example, improving the convergence performance or reducing the computational complexity, or implementing from scratch, it will help you to get a higher mark. You must apply your implementations to the routing path optimisation problem and critically evaluate the results, plotting the results in figures, illustration with figures/diagrams, and comparing and contrasting the performance, strengths, and weaknesses of the approaches you have used in terms of quality of the solution, running time, etc.

Dataset

The dataset for this assignment consists of one file:

1. sub_data_file.csv

The ***sub_data.csv*** file contains the following columns:

1st column: Node No. – such as 1, 2, 3, 4.
2nd column: coordinate x in a unit of meter.
3rd column: coordinate y in a unit of meter.
Note that the distance can be calculated as

$$d = \sqrt{(x2 - x1)^2 + (y2 - y1)^2}$$

Solution format

The solutions file should contain a list of routing paths and the value of the cost function in terms of the optimized objective.

An example touring path is given below (This is just an example, not a real optimized routing path):

{“Source node”: “Node-5”,
“routing path”: “(Node-2, 1 Mbps), (Node-1, 4 Mbps), (BS-2, 2 Mbps)”,
“End-to-end transmission rate”: “1 Mbps”}

where interpretation is as follows:
Node-5: is the source Node
(Node-2, 1 Mbps): The next relay node is Node-2, the data transmission rate between Node-5 and Node-2 is 1 Mbps.
(Node-1, 4 Mbps): The next relay node is Node-1, the data transmission rate between Node-2 and Node-1 is 4 Mbps.
End-to-end transmission rate: '1 Mbps': The end-to-end transmission rate is 1 Mbps.

Intended Learning Outcomes (ILOs)

This unit assesses your ability to:

1. Demonstrate knowledge and understanding of search and optimisation techniques and their applications.
2. Demonstrate critical awareness of the strengths and limitations of various stochastic search and optimisation techniques.
3. Implement search and optimisation solutions to real-world problems using modern algorithms and software libraries.
4. Design search and optimisation experiments and conduct rigorous statistical analysis of the results.

Submission Format:

Your submission must consist of:

1. **Report in the shape of a Jupyter notebook (Brightspace, Group),** that contains the following sections: *Introduction, Problem definition*, *Methodology (all steps)*, *Experiments & discussion, Conclusion, Future work* and *References*. The report must be a combination of text and working code, relevant figures (e.g. evolution of the objective function values over time), flowcharts/diagrams, tables and anything else you deem useful in communicating your work (e.g. interactive visualisations or animations). You must make sure that your notebook executes from top to bottom without any intervention. If there are errors, it will affect your marks.

2. **PDF version of your Jupyter notebook (Brightspace, Group).** This can be produced by simply printing your notebook to a *.pdf* file. You should make sure it is in the right format and layout.

3. **Solution files (Brighspace, Group)** representing your best solutions to the optimisation problems. The files should follow the format given in the section "Solution format".

4. **Acknowledgement of contributions (Brightspace, Group, but it should be signed by all members)**
   Each member of each group will be asked to acknowledge your contributions to the task in their respective group. A sample of "Acknowledgement of contributions" is available from Brightspace. "Acknowledgement of contributions" should be signed by all members. It is very important that you're honest in your assessment. The final mark will be weighted by your contribution.
5. **Poster (Brightspace, Individual)** of your group's submission, each one should individually complete a poster. You cannot submit the same poster as other group members. The poster should reflect your group's contributions and highlight the results. You can also highlight your personal contributions. This element is **mandatory**, and marks will only be awarded to those who submit the poster.

There will be three submission boxes, "Individual Poster", "Group Report" and "Group Large additional files".

1. **"Individual Poster"**: Each one should submit your poster to this box.

2. **“Group Report”**: PDF version of your Jupyter notebook should be submitted to this box.
3. **“Group Large additional files”**: A ZIP file includes 1) Report in the shape of a Jupyter notebook; 2) Solution files; 3) Acknowledgement of contributions.

How will this be assessed?

The following criteria will be used to assess the assignment:

Criteria	Comments	Available marks (100)	Relevant ILOs
Problem definition, Postulated deployment of Search and Optimisation (S&O) methods	• Problem definition and formulation • S&O requirements specification • Justification of S&O adopted methods • Clarity of objectives	10%	1,2
S&O implementations	• In-depth knowledge and understanding of S&O approach deployments • Implemented solver Completeness • Articulated evidence of covered constraints and Improvement of the S&O benchmark approaches • Visualized experimental/analytical results	25%	1,3,4
Coding	• Novelty of coding and good usage of software libraries • Embedded challenges and complexities for S&O implementation • Efficiency for S&O solver convergence	20%	3,4
Evaluation, validation and lessons learned	• Appraisal of achievement of project objectives. • Appraisal of achievement of a good understanding of S&O benchmarking in real-world problems • Conduct statistical tests and analyse • Quality of evaluation, validation, and lessons learned. • Quality of future recommendations	15%	1,2,4
Project report	• Document structure and coherence. • Literature support and references • Scholarship and clarity of narratives	15%	1,2,4
Poster	• Poster structure, layout, visual representations, coherence and quality	15%	1,2,3,4

The following sections describe what are the expectations for each level of achievement:

To achieve a Pass:
Attempt to solve the optimisation problem using at least two optimisation algorithms. Produce a reasonable report and fully run code that takes advantage of existing implementations or libraries. The report should reflect a decent understanding of

optimisation algorithms used. Each one should actively participate in the development of the project.

To achieve a higher mark:
Solve both optimisation problems using at least two optimisation algorithms. Produce an excellent report with details and fully running high-quality code implemented by yourselves. Visualize the routing path and key findings in a good format. Compare different optimisation algorithms in terms of mechanism and computational complexity as well as convergence.

Questions about the assessment:

You are encouraged to ask questions about the brief as early as possible, giving you the opportunity to achieve the best marks possible without any delay. The best way to ask questions is via Microsoft Teams.

Academic Integrity
The work you submit must be your own. Any attempt to gain an unfair advantage in your assessment by **cheating**, deception or fraud is considered an academic offence. The 'Assessment help and support' section of the unit (found under 'Assessment' in the content area) provides more guidance on avoiding academic offences, including **any guidance on what will or will not be considered an academic offence in this specific assessment**

Help and support
The 'Assessment help and support' section of the unit (found under 'Assessment' in the content area) provides information and guidance, including specific information on support for this assessment. It provides help with our policies on deadline extensions and information on support available in the university, including academic skills support and additional learning support for students with disabilities.

Disclaimer
The information provided in this assignment brief is correct at time of publication. In the unlikely event that any changes are deemed necessary, they will be communicated clearly via e-mail and via the VLE and a new version of this coursework brief will be circulated.

Date Issued: 30/09/2024

Group Assessment - Individual Contribution Form

Department of Computing & Informatics

Unit Title: SEARCH AND OPTIMISATION (COMP7065)

Element: Coursework 01 - Submission

This is a **mandatory form**, meaning that **ALL members MUST** submit the below form **INDIVIDUALLY** for the Unit Leader to consider when marking.

If there were significant issues with engagement or contribution from one or more group members adjustments will be made accordingly, based on the following principles:

- If there is **clear evidence** of engagement or contribution issues, the Unit Leader reserves the right to adjust any member's marks accordingly, based on the evidence **detailed in the form below**.
- If **only part of the group** submits this form:
  a. the Unit Leader reserves the right to adjust any member's marks accordingly, based on the evidence **detailed in the form below**.
  b. the Unit Leader reserves the right to award **zero marks** to any member who **does not** submit the below form.
- Any group where the forms submitted provide **insufficient information** to support Unit Leader to make a judgement, the Unit Leader reserves the right to award every group member an **equal mark**.
- Any group where the forms submitted provide **clear contradictory information**, the marks awarded will be at the discretion of the Unit Leader.

IMPORTANT: Every member of the group takes **full responsibility** to work collaboratively and professionally as a group. The Unit Leader will provide guidance on the next steps if there is a dispute between group members, Unit Leaders would not normally be expected to intervene to resolve disputes between group members.

Your Group Name or Number (According to Brightspace)				
Name and Student Number	**Contribution** (Please Circle)			**Comments** (Required when less than full contribution)
Your Name and Student Number	None	Partial	Full	
	None	Partial	Full	
	None	Partial	Full	
	None	Partial	Full	
	None	Partial	Full	
	None	Partial	Full	
	None	Partial	Full	
	None	Partial	Full	
	None	Partial	Full	

Your role within the group and actions/tasks which you completed or significantly contributed to:

Any other comments you would like to make on your group, particularly anything related to the group work:

Student Signature: _____ **Date:** ____ / ____ / _____