**ELEC3875 Bachelors Project**

# Project Proposal Form

# 2021-22

This form must be completed by the student and submitted online on Minerva **by 4pm on Friday of Week 7.** A link to submit this form will be available on the Module's Minerva page.

Guidelines on completing this form can be found in the module handbook 'How to propose your project'.

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| Name and SID: | Tarek Bessalah 201344887 |
| Degree programme: | BEng Electronics and Computer Engineering (Ind) |
| Supervisor's name: | Dr. Taisir Elgorashi |
| Project title: | Minimizing real-time emissions of distributed cloud services |

**Section 1: Project Description**

*Briefly, describe the basic background area, aims and objectives of your project (approx 600 words):*

The transformation of the information and communication industry brought by cloud and fog computing has been the primary focus of the related literature. However, literature in relation to minimising the overall CO2 emissions and appropriately placing renewable energy sources in different nodes has been available to a limited extent. This Individual Engineering project will produce a framework, through the utilisation of mixed integer linear programming (MILP) and heuristics, that would combat this issue. The British Telecom (BT) network topology will be considered, and will seek the optimum placement of virtual machine (VM) services from cloud to fog such that the emissions are minimized given a number of parameters.

Through different interfaces, cloud computing provides consumers access to a pool of virtualized and a continuum of scalable resources. The growing number of subscribers of cloud computing consequently generates voluminous raw data that needs to be processed, thus, a framework that minimises the associated carbon footprint has grown in importance. To minimize latency and bandwidth issues that come with cloud computing, fog computing is a proposed computing paradigm that consists of fog nodes, represented as either a hardware or a virtual components, that provide computing recourses along with network connection to the centralized cloud service. Fog computing acts as a connecting layer between smart-end devices, such as edge devices or sensors, and cloud services. VMs utilise the hypervisor to extract computing resources such as processing, storage facilities, and I/O of the underlying hardware. This virtual representation of computing resources is adopted in cloud computing as means for scalability to account for increased demand. Scalability is achieved by producing VM replicas on top of idle computing recourses. In addition, virtualization provides portability in which VMs can move to a physically different machine, thanks to the hardware abstraction provided by the hypervisor.

MILP is a form mathematical optimization that represents decision variables as integer variables that can be used to identify the maximum and the minimum of a solution. One thing to note is inefficiencies arise when taking into account many combinations of specific integer values. Decision variables can be represented as integers 1 or 0 (present or not present), and will be used to highlight a set of constraints. The placement of VM services will be simulated, under parameters such as CPU requirements, download traffic, and power usage effectiveness, in different nodes of the network topology in the access, metro, and core networks. The simulations will reveal the total power consumptions, thus, appropriate employment of renewable energy sources and different emissions can be identified and analysed.

The necessary material on cloud-fog computing paradigms, MILP, and heuristics will be researched first. In addition, literature on the correlation of the three factors mentioned with energy expenditure will be studied. Familiarity with the CPLEX software will be pursued, and a simple MILP model will be coded and debugged for learning purposes. The results obtained from a similar study, completed by the project supervisor, will be coded,

debugged and replicated. In addition, a list of constraints that could affect the optimization will be compiled. The development of simulations that considers the placement of a single VM will follow. A second scenario, with a realistic number of users in which average real-world figures, such as the broadband data rate, will be developed and compiled. The MILP will later be extended to consider the employment of renewable energy sources within the nodes.

The secondary objective of this project is to implement a practical solution, using MILP as benchmark, through heuristics. A supervised learning algorithm would be developed and tested, this involves the development of the online and offline phase. The objective would be to expand the heuristic into an application that allows users to manipulate the constraints that effect the model, and generate, in real-time, the total emissions. Ideally, this project will result in publication, as literature in this area is of limited extent.

## References:


1. ELGORASHI, T. and ALHARBI, H., 2020. *Energy Efficient Virtual Machines Placement Over Cloud-Fog Network Architecture*. [online] Ieeexplore.ieee.org. Available at: <https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9095288> [Accessed 10 November 2021].

2. Pioro, M. and Medhi, D., 2014. *Routing, Flow, and Capacity Design in Communication and Computer Networks*. Saint Louis: Elsevier Science, pp.1-200.

3. Iorga, M. and Goren, N., 2021. *Fog Computing Conceptual Model*. [online] Recommendations of the National Institute of Standards and Technology. Available at: <https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.500-325.pdf> [Accessed 9 November 2021].

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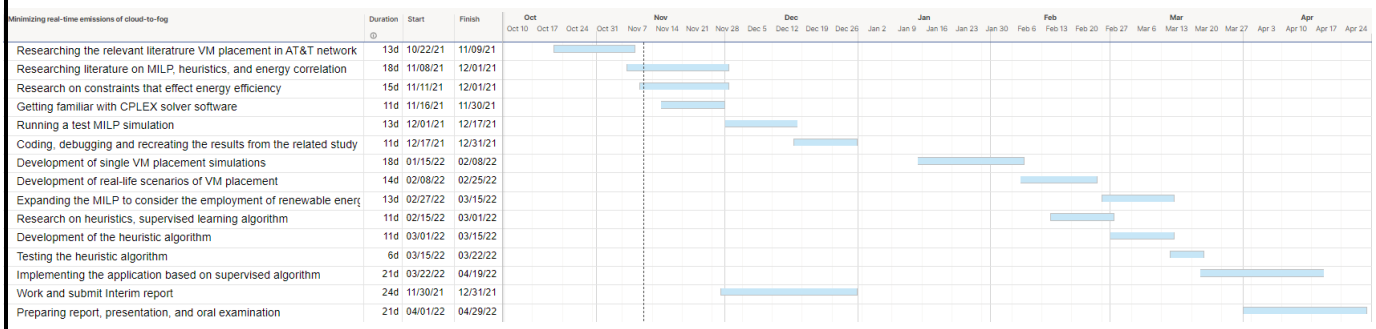
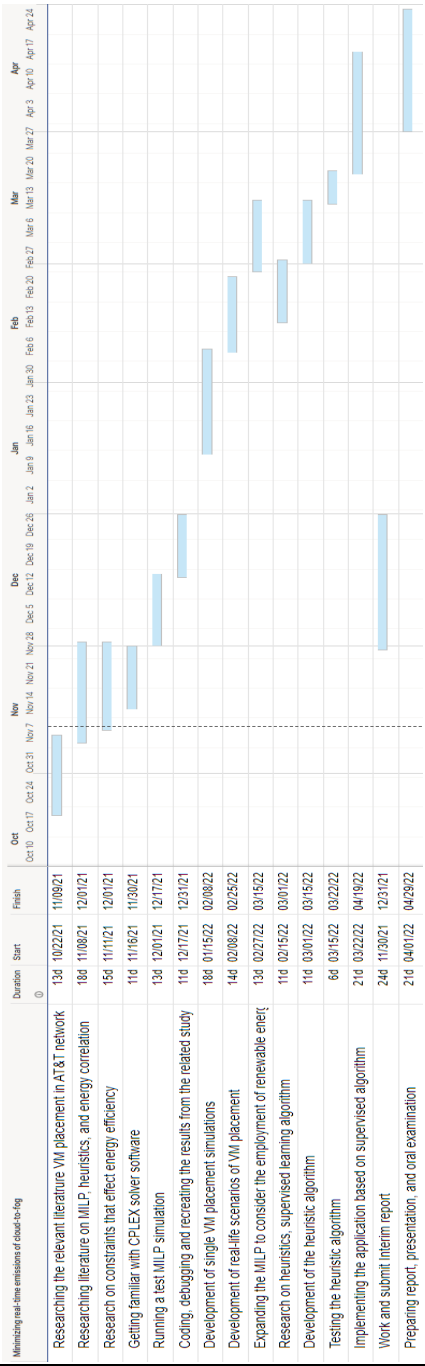
## Section 2: Gantt Charts

*Your Gantt chart should have clear timescales and relate to your progress milestones:*

*Please note the two images are the same, and is used to provide a bigger view of the contents*



| Minimizing real-time emissions of cloud-to-fog | Duration | Start | Finish |
|---|---|---|---|
| Researching the relevant literatrure VM placement in AT&T network | 13d | 10/22/21 | 11/09/21 |
| Researching literature on MILP, heuristics, and energy correlation | 18d | 11/08/21 | 12/01/21 |
| Research on constraints that effect energy efficiency | 15d | 11/11/21 | 12/01/21 |
| Getting familiar with CPLEX solver software | 11d | 11/16/21 | 11/30/21 |
| Running a test MILP simulation | 13d | 12/01/21 | 12/17/21 |
| Coding, debugging and recreating the results from the related study | 11d | 12/17/21 | 12/31/21 |
| Development of single VM placement simulations | 18d | 01/15/22 | 02/08/22 |
| Development of real-life scenarios of VM placement | 14d | 02/08/22 | 02/25/22 |
| Expanding the MILP to consider the employment of renewable energ | 13d | 02/27/22 | 03/15/22 |
| Research on heuristics, supervised learning algorithm | 11d | 02/15/22 | 03/01/22 |
| Development of the heuristic algorithm | 11d | 03/01/22 | 03/15/22 |
| Testing the heuristic algorithm | 6d | 03/15/22 | 03/22/22 |
| Implementing the application based on supervised algorithm | 21d | 03/22/22 | 04/19/22 |
| Work and submit Interim report | 24d | 11/30/21 | 12/31/21 |
| Preparing report, presentation, and oral examination | 21d | 04/01/22 | 04/29/22 |



## Section 3: Preliminary Resources Estimate

*Please supply as much information as you can (at this stage) about the resources you are likely to need.*

Will your project require the use of allocated bench space in a laboratory? No

Is your project likely to need the help of the Faculty Mechanical Workshop? No
(If 'Yes', describe briefly what this may involve)

Is your project likely to need the help of the Faculty Electronics Workshop? No
(Typically for printed circuit boards)

Will you need any special IT support? Yes

IT support could be needed to run the CPLEX solver to model the relevant MILP models, and due to the complexity of MILP models, the use of the high-performance computer, Polaris, might be needed as part of the research for this project. Using the help of the supervisor, the MILP model will be optimized.

Are you likely to need to purchase any special electronic components? No

## Section 4: Societal factors:

*Before completing this section, please refer to the notes on " Societal impacts" part of the handbook.*

### *Sustainability:*

How will you consider Sustainability aspects in your project (if relevant)? Justify why if you think "Sustainability" is non-relevant to your project.

The environmental impact of this proposed project is an overall positive outcome. This study aims to minimise the overall $CO_2$ emissions, and identifies areas, within the cloud-to-fog architecture, that a renewable energy source can be employed.

### *Ethics*:

*Please select one of the options below. Please refer to* www.leeds.ac.uk/ethics

Is the proposed project is believed to raise any ethical issues? No

If 'Yes', which one(s)? if "No" justify your answer?

### *Risk management:*

Identify, evaluate and risks (the effects of uncertainty) associated with your project and explain how you will mitigate their impacts.

The primary risk that stems from this project would be from the high complexity of the MILP model, which correlates to the number of constraints considered. This would put a computational strain on the Polaris machine that is running the model. This risk is mitigated with the help of a supervisor to simplify the model.

### *Equality, diversity and inclusivity:*

How will you consider equality, diversity and inclusivity aspects in your project (if relevant)? Justify why if you think these are not applicable to your project.

Equality, diversity, and inclusivity is relevant to human subjects, these implications would deem irrelevant to the proposed project as the research, simulation, and data points would primarily be gathered and modelled using physical hardware entities and virtualised computing elements in a given network topology. However, the parties involved in the project come from different backgrounds, and their opinions will be held at equally high consideration.

***Safety**:*

My project will require me to work in a specialist laboratory (e.g. B55b). No

If 'Yes', which one(s) and how regularly for how long? if "No" justify your answer?

**"I have attended the Safety Briefing (included in the ELEC3875 introductory lectures) and my attendance was recorded. I am aware that full Risk Assessments relating to project work within the School have been conducted. I agree to comply with all the relevant safety policies."**

Student signature: Tarek Bessalah ..... Date: 12/10/21 .....

*Before submitting this form your Supervisor should check and sign it.*

**"My student has completed this form satisfactorily and is aware of his/her safety responsibilities."**

Supervisor's signature: Taisir Elgorashi .....