

Detailed Project Proposal

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Defining your Project

1.1 Project title

Real-Time Operating System in Rust

1.2 Background

Help: Provide the background to your project. This section should highlight the main topics in the area you are going to research. Essentially what is the project about, what has been done before and why is this project important ? ~500 words

This project aims to create a real-time operating system using the Rust language. It addresses a large area of design techniques and algorithms so as to reach three defined goals :

- **deterministic** execution time of the programs (or subparts of them), allowing the processes to be managed accurately
- **correctness** of the time when a result is expected, to meet or miss the deadlines, where treatment marks the difference between soft and hard RTOS
- **predictability** of the deadline associated with a set of constraints to define an expected state of the system

These three concepts are the core characteristics of a RTOS, and will frame the tools used to evaluate the efficiency of such an OS. But a particular effort will be made to discuss the performance of the system, because elegant operations are marks of quality; and in the ways it is possible for the developer/user to interact with it, typically through a shell, for graphic UIs will not be covered in this project. Efficient multitasking is, as well, a core principle of the system, and hence a particular attention to the scheduling policy is required, as well as fast context switches to reduce the scheduler's overcost. Since almost each OS has its own solution to this problem, plenty of examples from different families of policies will be discussed.

Note that some of the popular classic OS, like Windows or GNU/Linux distributions, can be turned into a RTOS either by an extension (RTX and RTX64 for Microsoft Windows) or a microkernel (RTLinux for Linux). Apparently this is not a common solution, for they lack certain specificities when compared to their counterparts.

Such systems are very useful in several sectors, including astronautics, mainframes, aeronautics, robotics, or embedded systems in general (and IoT in particular), for the simple fact that they are highly reliable and almost never crash if they are well-designed. But yet they do not really suit a common daily usage for a regular user because they are task-oriented and not meant to be focused on user experience.

Concerning the Rust language, it is often cited as a potential successor of C++. Indeed, if C++ and Rust are quite close, especially regarding the syntax, the low-level orientation and the memory management, Rust already includes in-built concurrency management and safe operations on memory (that can be bypassed if needed). The community seems quite active, with many contributors and online places (forums, IRC channels, subreddit) where people exchange ideas. A YouTube channel also includes several conferences on specific topics. The most important operating system project written in Rust, Redox, is a microkernel Unix-like OS. There are also a few more projects, some of them for educational purposes, plus several kernels/microkernels, but no real-time OS. A review of these projects during the system's design process will be informative.

"The tools we use have a profound and devious influence on our thinking habits, and therefore on our thinking abilities" E. W. Dijkstra

It will also constitute a precedent in terms of combination of RTOS and Rust, useful in terms of computer science research. The programming language, a tool like any other, will have a deep influence on the final result. Rather than deny this relation, we choose to advantage profit of it, by selecting upstream the technological solution that will help to meet the goals.

1.3 Motivation

Help: To whom is this project important ? A project must address a question/problem that generates a small piece of new knowledge/solution. This new knowledge/solution must be important to a named group or to a specific client (such as a company, an academic audience, policy makers, people with disabilities) to make it worthwhile carrying out. This is the **motivation** for your project. In this section you should address who will benefit from your findings and how they will benefit. ~300 words

Example 1: If you intend to demonstrate that a mobile application that automates class registers at RGU will be more efficient than paper-based registers - the group who would be interested in knowing/applying these findings would be both academic and administrative staff at RGU and they would benefit by time saved and a reduction in their administrative workload.

Example 2: You are demonstrating that a particular 3D model design increases realism in 3D environments. The group that would be interested would be games designers or developers of 3D virtual environment applications. They would benefit from producing more realistic environments that could increase sales of their products.

Example 3: You have designed a new network topology for IrishOil plc's new Aberdeen headquarters. The interested group would clearly be IrishOil. They would benefit from easier maintenance and improved security of their computer network.

It seems that no real-time operating system have been written using this promising technology, probably because an important part of the companies that produce this kind of software started their business in the 80s and chose to use the relevant languages at this time, such as C/C++ with assembly. The advantages of Rust over C/C++ could significantly reduce the risks related to memory (segmentation fault, buffer overflow), keeping the flexibility of declaring variables on the heap or stack.

Embedded systems are sometime not easily replaceable or maintainable, for example a space probe sent to an asteroid, or an aircraft computer, and then are required to have the lowest dysfunction rate possible; for any events (in the processor instructions stream) leading the RTOS to become inoperative or have undefined behavior, even for a short time, can have disastrous consequences and represent a consequent loss of money or precious data. But such systems, because of their importance, are extremely sensitive to perturbations, and therefore have to be both well-designed and well-implemented, thus the choice of Rust in that case.

This RTOS will have as aim to offer, for companies or organisations working in the fields mentioned above, a safe and reliable framework to develop & deploy applications that fits their needs in terms of real-time operations. That's also why the license of this project, a public copyright Creative Commons license, allow to remix, transform, and build upon the material.

And finally, this project is really important for the student itself, long been interested in operating systems, and willing to create one. Even better, in a research context. Not to mention the potential applications in astronautics, one of his centers of interests, that makes the idea thrilling.

1.4 Aim & Objectives

Help: Outline what are the main things your project is going to do and what steps or milestones will be used to achieve this aim. The Aim is unlikely to change throughout your project; however, the objectives are likely to adapt to your ongoing research and development. In particular it is highly likely that you may wish to split objectives into sub-objectives as work progresses. A good clear set of objectives give you something to evaluate your final project against.

Example : For the timetable app outlined above

Aim: To create a functioning attendance application that efficiently automates the taking of class registers.

Objective 1: study existing register system in place at RGU and identify weaknesses

Objective 2: research existing automation technology's and identify and evaluate those that may be appropriate to taking in class registers

Objective 3: Implement chosen technologies to create prototype application

Objective 4: Conduct user trials to evaluate capabilities of prototype application

Objective 5: Create a refined application incorporating feedback from user trials

Aim : to create a functional real-time operating system using the Rust language with the following characteristics : **deterministic, correctness, predictability.**

Objective 1 : review theory and implementations of real-time operating systems

Objective 2 : familiarization with Rust

Objective 3 : implementation of the operating systems core components

Objective 4 : implementation of a shell

Objective 5 : testing the operating system

1.5 Key Techniques

Help: Perform some initial research into the area and outline what techniques you might research in further detail here. The techniques you cover here should include references to the papers where you have sourced the information. The techniques mentioned here are very likely to become the section headers in your literature review.

Microkernel OS architecture

Type of OS architecture where the kernel is as light as possible and only provide the necessary functions. Typically, clock driver, display driver, IPC, physical memory and scheduler. The kernel, services and programs communicate through IPC. - Hansen, P. (1970). The nucleus of a multiprogramming system. Communications of the ACM, 13(4), pp.238-241. - Wulf, W., Cohen, E., Corwin, W., Jones, A., Levin, R., Pierson, C. and Pollack, F. (1974). HYDRA: the kernel of a multiprocessor operating system. Communications of the ACM, 17(6), pp.337-345.

Scheduling algorithms

The implementation of this algorithm will manage the resources among the programs (including the processor itself) in order to minimize resource starvation and ensure fairness. - Liu, C. and

Layland, J. (1973). Scheduling Algorithms for Multiprogramming in a Hard-Real-Time Environment. Journal of the ACM, 20(1), pp.46-61. - Buttazzo, G. (2013). Hard real-time computing systems. 3rd ed. Johanneshov: MTM. - Lu, C., Stankovic, J., Son, S. and Tao, G. (2002). Real-Time Systems, 23(1/2), pp.85-126. - Meumeu Yomsi, P. and Sorel, Y. (2007). Extending Rate Monotonic Analysis with Exact Cost of Preemptions for Hard Real-Time Systems. 19th Euromicro Conference on Real-Time Systems (ECRTS'07).

JSON data format

Simple and widely used, this data format will be used by the processes to communicate with each other. These types of data are sufficiently generic and abstract to be represented in any programming language, on the one hand, and to represent any concrete data on the other. A library for Rust is available on GitHub under free software licenses (MIT or Apache 2.0 most of the time). - The JavaScript Object Notation (JSON) Data Interchange Format. (2017).

Asynchronous I/O operations

As the exchange of messages between processes will have a great importance, non-blocking I/O could significantly reduce the deadlocks. Further investigation on this topic is needed, but a polling system might be an interesting solution. - Colomiets, P. (2018). Asynchronous IO in Rust – Sudo vs Root. [online] Sudo vs Root. Available at: <https://blog.skcript.com/asynchronous-io-in-rust-36b623e7b965> [Accessed 27 Sep. 2018].

1.6 Legal, Social, Ethical, Professional and Security issues

Help: Here you should discuss any legal, social, profession and security issues that you believe may occur during the course of your project. It is not acceptable to write none in this box, all projects, regardless of focus will have to address issues in one, or more, of these categories. This is an extremely important part of your honours project to which there is no correct answer, this section must be fully discussed with your Honours Supervisor.

Example 1 : In the class register example above – there would be a Legal and Security issue with the gathering and storage of student data. There may be a social constraint as you may be relying on a user to have access to a specific technology. There will need to be consideration of user accessibility.

Example 2 : A 3D model design may have ethical considerations in its evaluation. What if your model made users feel nauseous. Social constrains may again be access to technology or accessibility issues.

Example 3 : You network design need to adhere to specific company policies. You would need to consider the possibility that your design could be wrong, compromising the company's security.

In case of a dysfunction of a software that runs on the RTOS and/or a product running the RTOS, causing damage to material and/or people, and/or leading to the destruction of the system that runs the RTOS, the responsibility does not lie with the programmer of the RTOS but rather with the physical person or corporation that have designed and/or created the product running the RTOS and/or the software running on the RTOS.

1.7 Project Plan

Help: This is the project plan as to how you will go about achieving the objectives of the project.

Example: In the class register example above the research plan may involve:

Collecting and analysing paper-based registers in a given class on five occasions.

Identifying the error rate average on these occasions

Researching existing automation techniques

Designing and implementing a mobile application that automatically records attendance in class.

Deploying the application in the class on five occasions.

Identifying the error rate average of the mobile application on these occasions.

Comparison of data and summary of findings.

Collecting and analysing research material and articles (including from professional-oriented blogs focused on programming) about RTOS

Gathering RTOS online code repositories to have an overview of the goals to reach and comparison elements

Learn and practice on a daily basis the Rust language through coding challenges websites

Designing and implementing the clock driver, display driver, IPC, physical memory manager and scheduler plus a few services

Designing and implementing and interpreter (containing a parser) for a Unix-like shell

Write unit tests for all the features and benchmark tests to measure the performances

1.8 Ethics Form

****You must include in your signed ethics form in this submission or you will not be able to continue the project.**

**STUDENT PROJECT ETHICAL REVIEW (SPER) FORM**

The aim of the University's *Research Ethics Policy* is to establish and promote good ethical practice in the conduct of academic research. The questionnaire is intended to enable researchers to undertake an initial self-assessment of ethical issues in their research. Ethical conduct is not primarily a matter of following fixed rules; it depends on researchers developing a considered, flexible and thoughtful practice.

The questionnaire aims to engage researchers discursively with the ethical dimensions of their work and potential ethical issues, and the main focus of any subsequent review is not to 'approve' or 'disapprove' of a project but to make sure that this process has taken place.

The *Research Ethics Policy* is available at www.intranet.rgu.ac.uk/credo/staff/page.cfm?pge=7060

Student Name	ANTHONY SEBERT
Supervisor	ANDREI PETROVSKI
Project Title	REAL-TIME OPERATING SYSTEM IN RUST
Course of Study	Computer Science
School/Department	Computing Science & Digital Media

PART 1: DESCRIPTIVE QUESTIONS

1.	Does the research involve, or does information in the research relate to: [see Guidance Note 1]	Yes	No
	(a) individual human subjects	<input type="checkbox"/>	<input checked="" type="checkbox"/>
	(b) groups (e.g. families, communities, crowds)	<input type="checkbox"/>	<input checked="" type="checkbox"/>
	(c) organisations	<input type="checkbox"/>	<input checked="" type="checkbox"/>
	(d) animals?	<input type="checkbox"/>	<input checked="" type="checkbox"/>
	Please provide further details:		
	n/a		
2.	Will the research deal with information which is private or confidential? [see Guidance Note 2]	Yes	No
		<input type="checkbox"/>	<input checked="" type="checkbox"/>
	Please provide further details:		
	n/a		

STUDENT PROJECT ETHICAL REVIEW (SPER) FORM

PART 2: THE IMPACT OF THE RESEARCH

3.	In the process of doing the research, is there any potential for harm to be done to, or costs to be imposed on: <i>[see Guidance Note 3(i)]</i>	Yes	No
	(a) research participants?		✗
	(b) research subjects? <i>[see Guidance Note 3(ii)]</i>		✗
	(c) you, as the researcher?		✗
	(d) third parties? <i>[see Guidance Note 3(iii)]</i>		✗
Please state what you believe are the implications of the research:			
n/a			
4.	When the research is complete, could negative consequences follow:	Yes	No
	(a) for research subjects		✗
	(b) or elsewhere? <i>[see Guidance Note 4]</i>		✗
Please state what you believe are the consequences of the research:			
n/a			

PART 3: ETHICAL PROCEDURES

5.	Does the research require informed consent or approval from: <i>[see Guidance Note 5(i)]</i>	Yes	No
	(a) research participants?		✗
	(b) research subjects? <i>[see Guidance Note 5(ii)]</i>		✗
	(c) external bodies? <i>[see Guidance Note 5(iii)]</i>		✗
If you answered yes to any of the above, please explain your answer:			
n/a			

STUDENT PROJECT ETHICAL REVIEW (SPER) FORM

6.	Are there reasons why research subjects may need safeguards or protection? [see Guidance Note 6]	Yes	No
			X
If you answered yes to the above, please state the reasons and indicate the measures to be taken to address them:			
n/a			
7.	Has PVG membership status been considered? [see Guidance Note 7]	Yes	No
(a) PVG membership is not required.		X	X
(b) PVG membership is required for working with children.			X
(c) PVG membership is required for working with protected adults.			X
(d) PVG membership is required for working with both children and protected adults.			X
If you answered yes to (b), (c) or (d) above, please give details:			
n/a			
8.	Are specified procedures or safeguards required for recording, management, or storage of data? [see Guidance Note 8]	Yes	No
			X
If you answered yes to any of the above, please give details:			
n/a			

PART 4: THE RESEARCH RELATIONSHIP

9.	Does the research require you to give or make undertakings to research participants or subjects about the use of data? [see Guidance Note 9]	Yes	No
			X
If you answered yes to the above, please outline the likely undertakings:			
n/a			

STUDENT PROJECT ETHICAL REVIEW (SPER) FORM


10.	Is the research likely to be affected by the relationship with a sponsor, funder or employer? <i>[see Guidance Note 10]</i>	Yes	No
			X
If you answered yes to the above, please identify how the research may be affected:			
u/a			

Part 5: Other Issues

11.	Are there any other ethical issues not covered by this form which you believe you should raise?	Yes	No
			X
u/a			

Statement by Student

I believe that the information I have given in this form is correct, and that I have addressed the ethical issues as fully as possible at this stage.

Signature:		Date:	19/09/2018
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If any ethical issues arise during the course of the research, students should complete a further Student Project Ethical Review (SPER) form.

The Research Ethics Policy is available at www.intranet.rgu.ac.uk/credo/staff/page.cfm?pge=7060

PART 6: TO BE COMPLETED BY THE SUPERVISOR

12.	Does the research have potentially negative implications for the University? <i>[see Guidance Note 11]</i>	Yes	No
			X
If you answered yes to the above, please explain your answer:			
u/a			

STUDENT PROJECT ETHICAL REVIEW (SPER) FORM

13.	Are any potential conflicts of interest likely to arise in the course of the research? <i>[see Guidance Note 12]</i>	Yes	No
			X
If you answered yes to the above, please identify the potential conflicts:			
n/a			
14.	Are you satisfied that the student has engaged adequately with the ethical implications of the work? [In signifying agreement, supervisors are accepting part of the ethical responsibility for the project]	Yes	No
		✓	
If you answered no to the above, please identify the potential issues:			
n/a			
15.	Appraisal: Please select one of the following		
i. The research project should proceed in its present form – no further action is required		✓	
ii. The research project requires ethical approval by the School Ethics Review Panel (SERP) (or equivalent)			
iii. The research project requires ethical review by the University's Research Ethics Sub-Committee			
iv. The project needs to be returned to the student for modification prior to further action			
v. The research project requires ethical review by an external body (N.B. Question 5 above). If this applies, please give these details:			
Title of External Body providing ethical review		n/a	
Address of External Body		n/a	
Anticipated date when External Body may consider project		n/a	

AFFIRMATION BY SUPERVISOR

I have read the student's responses and have discussed ethical issues arising with the student. I can confirm that, to the best of my understanding, the information presented by the student is correct and appropriate to allow an informed judgement on whether further ethical approval is required.

Signature:

[Signature]

/ A. PETROVSKI /

Date:

27/09/2018

① Guidance Note 1

Ethical principles normally apply to information, data, and derivative substances in the same way as they apply to the subjects themselves. Consequently, work with individual financial data is governed by the principles of work with individual human subjects, and work with animal tissue is governed by the principles of work with animals.

[\[return to Question 1\]](#)

① Guidance Note 2

The Australian National Health and Medical Research Council argues: "Individuals have a sphere of life from which they should be able to exclude any intrusion ... A major application of the concept of privacy is information privacy: the interest of a person in controlling access to and use of any information personal to that person." This principle applies to all information about a person, whether or not it is obtained directly from that person. The area that is private is conventional and culturally defined; in the UK it commonly includes income and family arrangements.

The information obtained in research is not, however, necessarily private. Some material is in the public sphere, which includes published and broadcast material, academic discourse, and the activities of government. Activities undertaken in a public place are public, rather than private, if they are openly displayed (e.g. artistic exhibition or attendance at a public event) or subject to public regulation (e.g. driving)."

[\[return to Question 2\]](#)

① Guidance Note 3

- (i) "Harm" refers to negative consequences beyond those which would occur in the normal course of events. Costs may include putting subjects under stress, causing them anxiety, or even wasting their time. The question asks only about potential harm. Potential harm is not cancelled out by potential benefit. Broader consequences are considered in the following question. Reviews of information are also subject to ethical consideration. It should never be assumed that no harm can be done to people simply by writing about them.
- (ii) "Research subjects" includes not just participants and informants but those about whom data is collected. The term covers any research subject, including humans, animals, and inanimate subject matter.
- (iii) The University has a responsibility to avoid putting you at risk, and potentially dangerous situations should always be drawn to the University's attention.
- (iv) "Third parties" include any person, group or organisation who may be affected by the process of the research.

[\[return to Question 3\]](#)

① Guidance Note 4

"Elsewhere" is an open category, intended to include consequences for third parties, sections of the community (e.g. "the voluntary sector"), the economy ("the catering industry") or the environment. ("the national park"), globally, and generalities which are harder to identify (e.g. "animal welfare"). Student researchers should never assume that their work is harmless only because they don't believe others will read it.

[\[return to Question 4\]](#)

① Guidance Note 5

- (i) Research in the public sphere (question 2) may not require the consent or approval of research subjects. The advice of the Canadian Tri-Boards is that "REBs (research ethics boards) should recognize that certain types of research - particularly biographies, artistic criticism or public policy research - may legitimately have a negative effect on organizations or on public figures in, for example, politics, the arts or business. Such research does not require the consent of the subject ... Consent is not required from organizations such as corporations or governments for research about their institutions".

There is a general presumption that consent should be obtained from subjects whenever the information is private. The requirement to seek consent can, however, be waived in certain exceptional cases, for example where there is necessary deception, or where the consent of a subject may jeopardise the welfare of an informant. All such cases require explicit ethical review and an extended justification.

(ii) The consent of research *subjects* cannot be presumed because the consent of *informants* has been obtained. For example, one member of a family cannot necessarily be taken to speak for others, and an employer cannot always give consent on behalf of employees.

(iii) The consent of *external bodies* is required for several types of research, including e.g.

- research relating to the NHS
- research for work with dangerous substances, and
- research involving experimentation with animals.

The existence of external consent does not ethically exclude the project from consideration by the University, or vice-versa. Please provide a brief description of the project as submitted to the external body for ethical review.

[\[return to Question 5\]](#)

① Guidance Note 6

This may apply, for example, to human subjects who are regarded as vulnerable (e.g. children or prisoners) and to animals. Consent should not be taken as sufficient protection.

[\[return to Question 6\]](#)

① Guidance Note 7

If your research will involve some form of work with children or protected adults or both, you may need to apply to join the Disclosure Scotland PVG Scheme. For further details and notes on applying please refer to www.rgu.ac.uk/about/governance/policies-and-legal/disclosure-scotland and www.disclosurescotland.co.uk/.

[\[return to Question 7\]](#)

① Guidance Note 8

Private data should be presumed to be under the control of the person or organisation to whom it relates. Anonymity is not a sufficient condition for confidentiality. Removing names from a report, or using aggregate data, may not be enough to ensure that respondents cannot be recognised or identified; and even where material is not identifiable except by the person who gave it, using it in ways that go beyond the terms on which it has been given may be a breach of trust.

[\[return to Question 8\]](#)

① Guidance Note 9

The integrity of the researcher, and the status of future research, requires that such undertakings should be respected. Promises should not be given in circumstances where they cannot be kept. For example, a researcher is not at liberty to conceal criminal activity and consequently cannot offer unconditional confidentiality in a study of such activity.

[\[return to Question 9\]](#)

① Guidance Note 10

Students who are undertaking research within the context of a work placement or employment should be aware that this is likely to have implications for the research and should identify what those implications are.

Sponsorship includes the grant of access to material by a responsible organisation.

[\[return to Question 10\]](#)

① Guidance Note 11

The University needs to know if the research may jeopardise its reputation through, for example, work for oppressive governments or other research relationships (e.g. work for tobacco firms) that might compromise or bias the research. Negative consequences in the form of criticism of the University or negative evaluations by students are legitimate potential outcomes.

[\[return to Question 12\]](#)

① Guidance Note 12

This includes, for example, conflicts between researchers, funders, stakeholders, employers and other research projects.

[\[return to Question 13\]](#)