TSN Research Proposal

# Target Objectives

In the project I would like to gain a good understanding of Time Sensitive Networks, their uses and the underlying technology. For this I believe it would be good to dedicate a portion of the project to explaining how they work. This includes explaining any accompanying technology such as the OSI networking layers, the 2 IEEE standards, and just general models of TSNs with pros and cons compared to the current technology we use in industrial settings (CAN busses). I think with the comparison to the current technology it may also be beneficial to explain the further uses beyond industrial settings such as the automotive industry and even smart cities.

Then I would like to get more into the technical side and explore current simulation techniques in software and their advantages/disadvantages compared with one another. Then improve upon any software simulations, adding more features to them so I can investigate the main goal of my project which is optimising schedules. If I have enough time it may be beneficial to investigate using real hardware to model the TSN, but this may be too complicated for the timescales of the project. We will just have to see, but I will be using software simulation at a minimum.

The main focus of the project would be to study adaptive load management for TSNs in an overloaded condition. For this I will have to explore different ways of scheduling and mapping the TSN flows as well as different optimisation techniques. I don’t know much about this yet, but I imagine this is where the bulk of the work will be. I would first have to explore the theory behind the methods in depth or at least a reasonable level of abstraction reinforced by the first major objective.

After exploring the theory, I would have to then actually model them in simulation and analyse the effectiveness of each one, showing the benefits and drawbacks of each solution. I would like to have at least 2 different methods of scheduling/mapping problems, and at least 2 methods of adaptive load management for an overloaded system.

In conclusion, 4 major objectives:

* Explain TSNs and understand the underlying technology
* Expand on current software simulation techniques and prototype a hardware model if time permits
* Study theory on adaptive load management in an overloaded system, and theory on scheduling and mapping TSN flows. Expanding on it and creating my own theoretical methods
* Implement theoretical methods in a chosen simulation model and draw any scientific conclusions from it.

# How the Project Affects Others

The project itself will generate a new way to simulate TSNs. This will either be an expanded-on version of a currently existing simulation tool by implementing new features (if I get permission to do so), or a completely new tool. This tool could be used by others if we find a way or need to publish it. This means that other people in this field could end up using or expanding on my tool to simulate and evaluate their own theoretical methods. The tool itself would be more useful if it generated statistics of the network topology.

If my theoretical methods give promising results under my simulations, they may be investigated further and contributed to by others. Either by simulating the methods in different ways to validate them under different environments, or by simply being altered/expanded on and improved if possible.

Also, if the scheduling methods turn out to have sufficient/exact tests then these could actually be used and implemented in industry. Also, if my optimisation for overflowed systems method proves useful under simulation that may also be used and implemented. Realistically, however, they will likely just be improved upon by experts in the field and then published in less abstract papers, but it may mean that I give somebody the idea to create a better algorithm which I think would be great contribution to the world of TSNs.

# Contents List of the Report

I want the main flow of the report to be:

Explain TSNs -> Build HW/SW Simulation -> Propose Theoretical Methods -> Simulate and Analyse

I have thought of a lot of subsection headings, some may be used/altered, and some may be dropped but here is my list along with explanations of the context. As I haven’t started learning about TSNs yet, I am unfamiliar with what is required for some of the theoretical sections so any help here in identifying flaws would be useful at this early stage.

Explaining TSN Section:

* Introduction
* Objectives
* The OSI Model
* What is a TSN?
  + Very abstract
* The IEEE Protocols
  + IEEE 802.1Qbv and IEEE 802.1Qbu explained fairly in depth
* CAN Busses
  + The current industrial standard that TSNs will hopefully replace one day
  + Explaining pros and cons of this compared to TSN
  + Maybe explaining how we will switch to TSN from these CAN busses
* Further Uses
  + Automotive, smart cities, others?
  + A shorter and more abstract section
  + I could possibly group this and the CAN bus section and have sub-sections in-between

Simulation Section:

* Investigating Pre-Existing Software Simulators
  + A breakdown of current ways we simulate TSNs and what they are missing
* Improving Pre-Existing Simulators
  + This will be explaining the methodology of why I am adding features to current simulators, why I need certain aspects and certain outputs assuming they are missing
* Creating a Hardware Model [Time Permitting]
  + This will be time dependant. If I get far enough into the project and feel there is enough time to investigate if this is possible with the remaining time it could be a good exercise, but it is not the primary goal
* Modelling TSN flows
  + Possible section to model a basic TSN to prove functionality that my new simulator will be suitable for use later in the project

Theoretical Section:

* Adaptive Load Management in an Overloaded Condition
  + This will be a large section showing my methodology of adapting current algorithms or creating new algorithms to deal with overloaded TSNs via dynamic configuration
  + I do not know much about this yet, or what it entails but I assume it will be the bulk of the work
* Scheduling and Mapping TSNs
  + Investigating methods of optimisation to satisfy a TSN flow via different scheduling and mapping methods
  + Again, as this is the main learning part of the module these sections can easily change and will probably be the bulk of the work. I don’t fully know what will happen in these sections, as I haven’t learned about them.
  + The goal for this Theoretical Section is to propose algorithms to be tested and analysed in my simulator
* How Quality of Service can improve non-critical Traffic
  + In the objectives on the project page this was mentioned
  + So far, I understand it to be a way of maintaining the time-sensitive critical parts the network, whilst causing the least amount of disruption to regular traffic
  + Alternatively explained as: How QOS could be used to improve non time-critical traffic whilst still satisfying scheduled flows of time-critical traffic

Evaluation Section:

* Evaluating Adaptive Load Management Algorithms
  + This section I would implement the theory from the previous section and analyse it, saying how it could be useful in some situations more than others
* Evaluating Scheduling and Mapping Algorithms
  + Same as previous heading but for a different kind of algorithm
  + Each problem will have its own section where we will explore building the simulation, the methodology behind it, the output of the simulation, analysing the output, drawing scientific conclusions from this output
* Hardware Modelling
  + If possible, I can try to implement an algorithm in real hardware and see how it compares to the software simulations, drawing further conclusions and verification. Time permitting

# System Evaluation

After proposing theoretical methods and explaining what data I need from my simulations, I will use the simulators to validate that the theoretical methods work and then examine their efficiency and see if they are fit for purpose.

This will mean that the simulators will need appropriate tests under simple conditions to make sure the function is correct and then further tests under more complex situations. Once I have validated the simulator, I can build my theoretical methods to get some output that I can analyse further. The output from the simulators will be the main way of evaluating the algorithms.

I will check to make sure all requirements of a flow are met, and that other traffic is not disrupted beyond actual use. I need to check the complexity of the problem to make sure it is scalable and feasible for decently sized networks and that it is still schedulable.

Ideally, I would compare the software simulations to a hardware simulation but there may not be enough time for this.