School of Computer Science and Engineering

Faculty of Engineering

The University of New South Wales

Blockchain-based Carbon Market

by

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Thesis submitted as a requirement for the degree of

Bachelor of Science in Computer Science and Engineering
(Honours)

Abstract

Emissions trading schemes (ETS) are a policy tool at the forefront of the fight against climate change. In this thesis, I will present a blockchain-based approach for creating a carbon market driven by hydrogen certificates. By using carbon tokens, an effective price can be placed on the use of carbon removing a market failure existing in the production of natural resources. I will use a high-throughput permissioned blockchain to motivate how trust can be placed in a market made volatile by inconsistent government policy and scepticism on the behalf of participants.

Abbreviations

BE Bachelor of Engineering

LaTeX A document preparation computer program

PhD Doctor of Philosophy

Contents

List of Figures

List of Tables

Chapter 1

Introduction

A blockchain can be defined as an immutable ledger maintained by a network of mutually untrusting peers. Since the creation of Bitcoin (BTC) in January 2009 by the maverick Satoshi Nakamoto there has been an explosion of interest in the underlying technology behind blockchains. Specifically, the immutability and openness of the distributed ledger makes blockchain an attractive option for markets with untrusting participants exposed to information asymmetry. The market for carbon is particularly well suited to the blockchain due to inconsistent government policy - for example the ill-fated outcome of the Carbon Pollution Reduction Scheme in Australia.

Recent attempts to create blockchain-based carbon markets have been met with some success - but have been held back by technicalities or innovations that disrupt the fundamental goal of using the blockchain as a 'trust machine'. I will outline how hydrogen certificates on the blockchain can be used to automatically spend carbon tokens and add extra validation before being sold on the commodity market. Hydrogen is particularly well-suited as an example for certificate-based carbon markets due to hydrogen producers attaching a carbon footprint to certificates.

I will outline how permissioned blockchains are principally useful for carbon markets due to support for high-throughput transactions. A carbon market would have to scale to a large number of distributed producers with scalability matching hydrogen energy

production - an industry expected to be worth USD155 billion by 2022. I will propose Hyperledger Fabric as a blockchain framework - chiefly due to its support for up to 3500 transactions per second (TPS) and a plugable consensus algorithm. Moreover, my proposed solution will accommodate an optional carbon 'reputation' as part of the price for exchanging carbon tokens between producers.

In Chapter 1 an overview of the thesis and its novel approach to certificate-based carbon markets is presented. In Chapter 2 I outline the background to the project and important literature for markets on a blockchain. In Chapter 3 I provide methodology for the blockchain architecture. In Chapter 4 I outline some preliminary results with creating smart contracts (programs on the blockchain) for auctions on a public blockchain. In Chapter 5 I conclude with some remarks on the future potential for the thesis topic.

Chapter 2

Literature Review

Every semester, students ask their supervisor how to write their thesis, what the requirements are, and what to write in it. This document tries to answer all such questions.

2.1   Literature Review

Previously, Nooshabadi [Noo05] has descried style-related thesis requirements, Shepherd [She05] has provided LaTeX templates while other academics have discussed contents with their students. This work draws all the relevant information regarding thesis writing into one document. The present template/document is heavily influenced by Nooshabadi and Shepherd, incorporating requirements from The Graduate Research School [GRS14] for Higher Degree Research theses.

Chapter 3

Project Plan

Requirements for other parts of the thesis work can be found on the school web-pages [Noo05]. The requirements below are for the written thesis only.

3.1   Format

The following format specifications must be adhered to for your thesis (the LaTeX template available from the school ensures this):

1. The thesis must be written on *A4 size paper.*

2. The thesis must be typed or prepared using a *word-processor.*

   - For Undergraduate theses, you are encouraged to use both sides of the paper.

   - For Higher Degree Research theses, your submitted thesis must be printed single-sided.

3. *Margins* on all sides must be no less than 20 mm (before binding).

4. *1.5 line spacing* (about 8 mm per line) must be used.

5. All sheets must be *numbered*. The main body of the thesis must be numbered consecutively from beginning to end. Other sections must either be included or have their own logical numbering system.

6. The *title page* must contain the following information:

   (a) University and School names.

   (b) Title of Thesis/Project.

   (c) Name of Author and student ID.

   (d) The degree the thesis is submitted for.

   (e) Submission date (month and year).

   (f) Supervisor's name (for undergraduate theses).

7. After the body of the thesis, the thesis *must* contain a Bibliography or References list as appropriate.

   Authors should confer with their supervisors and School about the style of their bibliography, as this varies between disciplines.

3.2   Other physical appearance

Other requirements to the physical appearance of your theses are:

1. *Graphs, diagrams and photographs* should be inserted as close as possible to their *first reference* in the text. Rotated graphs etc are to be arranged so as to be conveniently read, with the bottom edge to the outside of the page. *Graphs and diagrams must be legible!*

2. *Supplementary material (for example CFD animations)* may be submitted either online or via external drive, and must be referred to within the text. The text should make sense without the supplementary material available.

3.3   Submission

Finally, here are some requirements to the submission procedure.

1. The *author* of the thesis is *responsible* for the preparation of the thesis before the deadline, proofreading the typescript and having corrections made as necessary.

2. For undergraduate theses, there is a *page limit* of 50 pages for the main body of the thesis.

Chapter 4

Project Dependent Preparations

This chapter is mainly provided for the purpose of showing a typical thesis structure. There are no more thesis requirements described.

4.1 Results

The result of this work is the present document, being both a LaTeX template and a thesis requirement specification.

4.2 Discussion

The Dual function of this document somewhat de-emphasises the primary purpose of the document, namely the thesis requirements. It would be better, if these could be stated on a few concise pages (cf Appendix 1, p10).

Chapter 5

Conclusion

A thesis requirements/template document has been created. This serves the dual purposes of giving students specific requirements to their theses — both style and content related — while providing a typical thesis structure in a LaTeX template.

5.1   Future Work

Extract the requirements from the template in order to have very concise requirements.

Bibliography

[GRS14] GRS. Thesis format guide: A guide for candidates preparing to submit their thesis for examination. https://research.unsw.edu.au/document/thesis_format_guide.pdf, accessed 14/04/2015, 2014. Graduate Research School, UNSW.

[Noo05] Saeid Nooshabadi. Bachelor of engineering thesis and project: timetable and notes for students. http://scoff.ee.unsw.edu.au/document/thesis/thnotes2.pdf, accessed 14/11/2005, 2005. School of El. Eng. and Telecom., UNSW.

[She05] John Shepherd. Doing a cse thesis. http://www.cse.unsw.edu.au/~jas/talks/thesis/, accessed 14/11/2005, 2005. School of Comp. Sci. and Eng., UNSW.

Appendix 1

This section contains the options for the UNSW thesis class; and layout specifications used by this thesis.

A.1   Options

The standard thesis class options provided are:

undergrad	default
hdr	
11pt	default
12pt	
oneside	default for HDR theses
twoside	default for undergraduate theses
draft	(prints DRAFT on title page and in footer and omits pictures)
final	default
doublespacing	default
singlespacing	(only for use while drafting)

A.2   Margins

The standard margins for theses in Engineering are as follows:

	U'grad	HDR
\oddsidemargin	40 mm	40 mm
\evensidemargin	25 mm	20 mm
\topmargin	25 mm	30 mm
\headheight	40 mm	40 mm
\headsep	40 mm	40 mm
\footskip	15 mm	15 mm
\botmargin	20 mm	20 mm

A.3   Page Headers

A.3.1   Undergraduate Theses

For undergraduate theses, the page header for odd numbers pages in the body of the document is:

Author's Name	*The title of the thesis*

and on even pages is:

The title of the thesis	Author's Name

These headers are printed on all mainmatter and backmatter pages, including the first page of chapters or appendices.

A.3.2   Higher Degree Research Theses

For postgraduate theses, the page header for the body of the document is:

The title of the chapter or appendix

This header is printed on all mainmatter and backmatter pages, except for the first page of chapters or appendices.

A.4   Page Footers

For all theses, the page footer consists of a centred page number. In the frontmatter, the page number is in roman numerals. In the mainmatter and backmatter sections, the page number is in arabic numerals. Page numbers restart from 1 at the start of the mainmatter section.

If the **draft** document option has been selected, then a "Draft" message is also inserted into the footer, as in:

14	**Draft:** April 27, 2021

or, on even numbered pages in two-sided mode:

Draft: April 27, 2021	14

A.5   Double Spacing

Double spacing (actualy 1.5 spacing) is used for the mainmatter section, except for footnotes and the text for figures and table.

Single spacing is used in the frontmatter and backmatter sections.

If it is necessary to switch between single-spacing and double-spacing, the commands `\ssp` and `\dsp` can be used; or there is a `sspacing` environment to invoke single spacing and a `spacing` environment to invoke double spacing if double spacing is used for the document (otherwise it leaves it in single spacing). Note that switching to single spacing should only be done within the spirit of this thesis class, otherwise it may breach UNSW thesis format guidelines.

A.6   Files

This description and sample of the UNSW Thesis LaTeX class consists of a number of files:

unswthesis.cls	the thesis class file itself
crest.pdf	the UNSW coat of arms, used by `pdflatex`
crest.eps	the UNSW coat of arms, used by `latex + dvips`
dissertation-sheet.tex	formal information required by HDR theses
pubs.bib	reference details for use in the bibliography
sample-thesis.tex	the main file for the thesis

The file sample-thesis.tex is the main file for the current document (in use, its name should be changed to something more meaningful). It presents the structure of the thesis, then includes a number of separate files for the various content sections. While including separate files is not essential (it could all be in one file), using multiple files is useful for organising complex work.

This sample thesis is typical of many theses; however, new authors should consult with their supervisors and exercise judgement.

The included files used by this sample thesis are:

definitions.tex	mywork.tex
abstract.tex	evaluation.tex
acknowledgements.tex	conclusion.tex
abbreviations.tex	appendix1.tex
introduction.tex	appendix2.tex
background.tex	

These are typical; however the concepts and names (and obviously content) of the files making up the matter of the thesis will differ between theses.

Appendix 2

This section contains scads of supplimentary data.

B.1   Data

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