

Smart Contracts for e-Learning



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I would like to dedicate this paper to Mum, Dad, Vivien, Viviana and Jorden.

Abstract

The properties of a distributed ledger could bring new features to e-Learning. Properties such as immutability and peer executed smart contracts could bring a new level of trust, transparency and personalisation to the education market.

This project focused on features that would improve the experiences of students and teachers in assessments, and curriculum personalisation. They were identified as two of the key concerns in the current UK higher education industry that can be improved by a distributed ledger powered e-Learning platform.

The logic of the smart contracts and data models for such a platform were proposed. A working prototype was also developed based on the IBM Hyperledger Composer project.

Acknowledgements

I would like to acknowledge the people listed below (in alphabetical order) for their time and effort spent on helping me complete the project:

- Dr. Fang Wang
- Prof. Rob Macredie

The formatting of this report is done by branching Krishna Kumar's Cambridge University Engineering Department PhD thesis LaTeX template on GitHub, and with reference to a Microsoft Word template provided by Dr. Simon Kent.

Declaration

I hereby declare that except where specific reference is made to the work of others, the contents of this dissertation are original and have not been submitted in whole or in part for consideration for any other degree or qualification in this, or any other university. This dissertation is my own work and contains nothing which is the outcome of work done in collaboration with others, except as specified in the text and Acknowledgements.

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Academic Year 2017 - 2018

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Chapter 1

Introduction

The global e-Learning industry already generates US\$60 billion per year, and by 2019, over half of all courses will be taken online (Pantò and Comas-Quinn, 2013, p.17). This rising trend presents an opportunity to improve higher education.

Some current problems in higher education are related to transparency. [TODO: what is transparency?] Tension exists between the educational provider and the learners over assessments. "There is abundant evidence that assessors are not particularly good at making exams valid, reliable, or transparent to students." (Brown Jr, 1999, p.62).

There is also a lack of curriculum personalisation for higher education learners in the UK [TODO: due to..., ref Rob] Condie and Munro (2007) pointed out that the personalisation of the education curriculum for learners helps "overcome barriers, raising self-esteem and achievement". Current web, mobile and computer technologies today can provide more personalisation of education curricula, but lacks [TODO: common marketplace? promise of delivery? transparency for employers?]

Being able to deliver education curricula and conduct assessments in a transparent, conflict-free way would be central to a future e-Learning marketplace that is open, trusted

and autonomous. This is where immediate value could be provided by distributed ledger systems and smart contracts.

A distributed ledger is a type of database that is spread across multiple sites, such as different institutions, companies or participants. Validators or operators of this ledger are trusted not to collude and defraud actors in a transaction. The technology enabling this distributed ledger is popularly known as a blockchain, where a block of records is chained to the next with a cryptographic signature, creating immutable records through a consensus corroborate by all the operators. (Walport, 2016, p.17) The security, immutability and verifiability of all actions on a blockchain provides the system with maximal transparency.

Smart contracts are "contracts" that are "defined by the code and executed (or enforced) by the code" (Swan, 2015, p.16). They are logic embedded in a blockchain that defines the rules and penalties around an agreement and automatically enforce those obligations (Gulhane, 2017), and can be used to exchange or transfer digital assets when certain conditions are met.

The potential of blockchain enabled systems in education has been noted by the community, with Swan (2015, p.62) proposing that “learning smart contracts could automatically confirm the completion of learning modules through standardized online tests”. Appropriate configurations in permissions and visibility can also provide improved security and privacy to e-Learning.

1.1 Aims and Objectives

Designing a system that fulfill educational assessments and rewards with publicly visible smart contracts on a blockchain.

The ideal system will enable the exchange of modular smart contracts provided by education providers, executed by the peer network. This will facilitate the negotiation and

fulfillment of personalised learning plans, guarantee the openness and fairness of assessment and rewards, and increase trust in educational credentials. The project will:

- Discuss the role of smart contracts in e-Learning
- Design smart contracts for the proposed scenario
- Build a demonstrator that includes: a small network of peers hosted on containers one example course containing two or more modular smart contracts a client-side application that allows e-learners to invoke learning actions a public facing application that allows queries to e-Learning smart contracts

Here you should clearly define the overarching aim for your project. Usually, for a final year project, you will have a single aim.

You should then list, the necessary and complete set of objectives that you will need to achieve in order to satisfy the aim:

1. Undertake a relevant background study to identify existing work in the area, and to identify appropriate techniques which can be adopted to produce a solution in this project.
2. Identify an approach which, when executed, will give rise to results from which rigorous conclusions can be drawn.
3. Design and implement some software, or undertake a simulation, or business modeling exercise, or conduct some other kind of appropriate activity which will give rise to the results desired.
4. Tailor the generic objectives to make them relevant for your specific project. Generic aims and objectives will lead to low-grading, generic project.
5. Evaluate the results using an appropriate framework, or set of success criteria which are clearly related to the problem and stated aim.

1.2 Project Approach

Describe how the project will be undertaken. Remember that the way in which you conduct your project will dictate the nature of the results that you produce, and the corresponding

conclusions you can draw from them. This is why it is important that your reader understands how you are going about your project from an early stage, so they can understand how to interpret your results. • Review literature on e-Learning and assessments • Design the parameters and functions of the smart contract on the IBM Hyperledger Composer • Implement the system on a local Docker peer cluster • Implement the learner and public facing applications

1.3 Dissertation Outline

Traditionally, dissertations tend to contain a description of each chapter:

Chapter 2, discusses the background for my project, and identifies some key techniques that can be adopted during the development of the proposed solution. Chapter 3 explains how the project will be undertaken . . . etc, etc.

This approach is acceptable, however it can make quite bland reading. You might like to consider drawing a flow-chart of your project, showing how information such as background data, questionnaire data, results of studies, running computer programs, or undertaking user studies act as input to, or output from your chapters. You can also indicate how each chapter relates to your objectives. This kind of diagram can help to add clarity for your reader, and can help you to get your head round the structure of your project.

Chapter 2

Background

2.1 Reasonably long section title

I'm going to randomly include a picture Figure 2.1.

If you have trouble viewing this document contact Krishna at: kks32@cam.ac.uk or raise an issue at <https://github.com/kks32/phd-thesis-template/>

Enumeration

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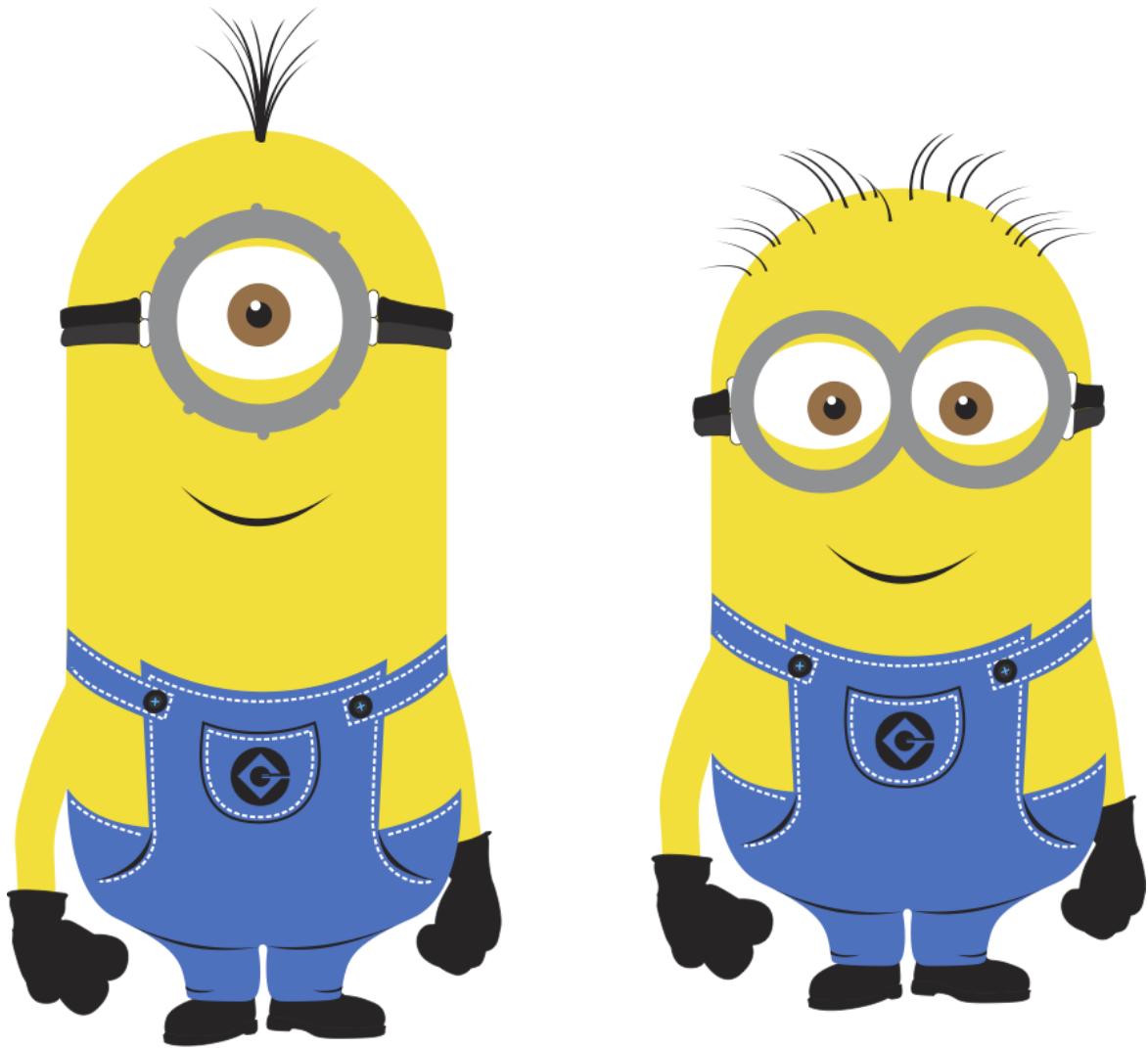


Fig. 2.1 This is just a long figure caption for the minion in Despicable Me from Pixar

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2. The second topic is duller
 - (a) The first subtopic is silly
 - (b) The second subtopic is stupid

3. The third topic is the dullest

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- The second topic is duller
 - The first subtopic is silly
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- The third topic is the dullest

Description

The first topic is dull

The second topic is duller

The first subtopic is silly

The second subtopic is stupid

The third topic is the dullest

2.2 Hidden section

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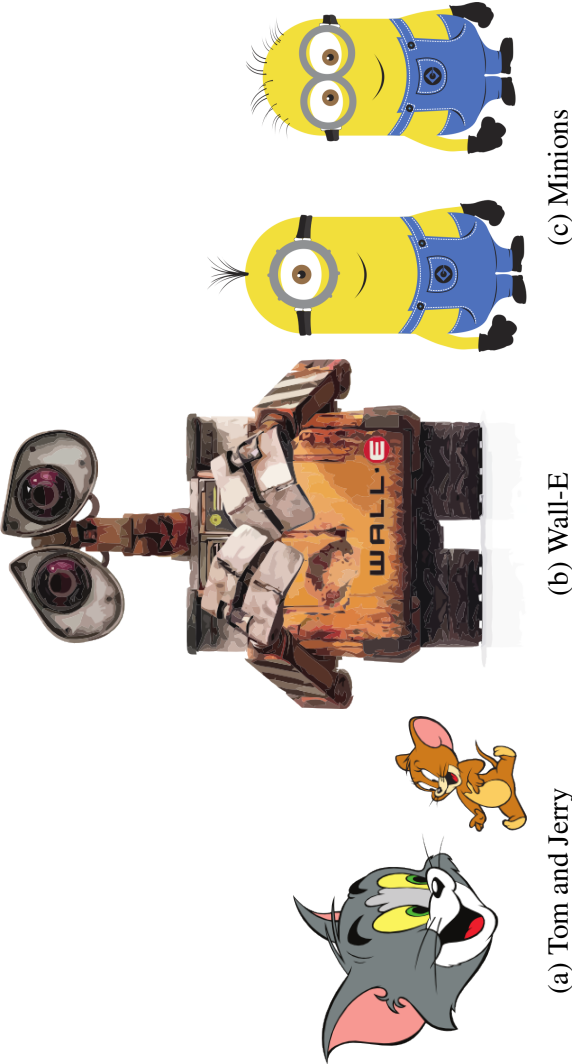


Fig. 2.2 Best Animations

Subplots

I can cite Wall-E (see Fig. 2.2b) and Minions in despicable me (Fig. 2.2c) or I can cite the whole figure as Fig. 2.2

Chapter 3

Methodology

3.1 First section of the third chapter

And now I begin my third chapter here ...

And now to cite some more people Ancey et al. (1996); Read (1985)

3.1.1 First subsection in the first section

...and some more

3.1.2 Second subsection in the first section

...and some more ...

First subsub section in the second subsection

...and some more in the first subsub section otherwise it all looks the same doesn't it? well
we can add some text to it ...

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First subsub section in the third subsection

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Second subsub section in the third subsection

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3.2 Second section of the third chapter

and here I write more ...

3.3 The layout of formal tables

This section has been modified from “Publication quality tables in \LaTeX ” by Simon Fear.

The layout of a table has been established over centuries of experience and should only be altered in extraordinary circumstances.

When formatting a table, remember two simple guidelines at all times:

1. Never, ever use vertical rules (lines).
2. Never use double rules.

Table 3.1 A badly formatted table

	Species I		Species II	
Dental measurement	mean	SD	mean	SD
I1MD	6.23	0.91	5.2	0.7
I1LL	7.48	0.56	8.7	0.71
I2MD	3.99	0.63	4.22	0.54
I2LL	6.81	0.02	6.66	0.01
CMD	13.47	0.09	10.55	0.05
CBL	11.88	0.05	13.11	0.04

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A frequently seen mistake is to use ‘`\begin{center}`’ ... ‘`\end{center}`’ inside a figure or table environment. This center environment can cause additional vertical space. If you want to avoid that just use ‘`\centering`’

Table 3.2 A nice looking table

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Chapter 4

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Chapter 5

Methodology

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CBL	11.88	0.05	13.11	0.04

Chapter 6

Evaluation

Chapter 7

Conclusion

7.1 Future Work

and here I write more ...

References

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Appendix A

How to install L^AT_EX

Windows OS

TeXLive package - full version

1. Download the TeXLive ISO (2.2GB) from
<https://www.tug.org/texlive/>
2. Download WinCDEmu (if you don't have a virtual drive) from
<http://wincdemu.sysprogs.org/download/>
3. To install Windows CD Emulator follow the instructions at
<http://wincdemu.sysprogs.org/tutorials/install/>
4. Right click the iso and mount it using the WinCDEmu as shown in
<http://wincdemu.sysprogs.org/tutorials/mount/>
5. Open your virtual drive and run setup.pl

or

Basic MikTeX - T_EX distribution

1. Download Basic-MiK_TE_X(32bit or 64bit) from
<http://miktex.org/download>
2. Run the installer
3. To add a new package go to Start » All Programs » MikTeX » Maintenance (Admin)
and choose Package Manager

4. Select or search for packages to install

TexStudio - T_EX editor

1. Download TexStudio from
<http://texstudio.sourceforge.net/#downloads>
2. Run the installer

Mac OS X

MacTeX - T_EX distribution

1. Download the file from
<https://www.tug.org/mactex/>
2. Extract and double click to run the installer. It does the entire configuration, sit back and relax.

TexStudio - T_EX editor

1. Download TexStudio from
<http://texstudio.sourceforge.net/#downloads>
2. Extract and Start

Unix/Linux

TeXLive - T_EX distribution

Getting the distribution:

1. TeXLive can be downloaded from
<http://www.tug.org/texlive/acquire-netinstall.html>.
2. TeXLive is provided by most operating system you can use (rpm,apt-get or yum) to get TeXLive distributions

Installation

1. Mount the ISO file in the mnt directory

```
mount -t iso9660 -o ro,loop,noauto /your/texlive####.iso /mnt
```

2. Install wget on your OS (use rpm, apt-get or yum install)
3. Run the installer script install-tl.

```
cd /your/download/directory
./install-tl
```

4. Enter command 'i' for installation
5. Post-Installation configuration:
<http://www.tug.org/texlive/doc/texlive-en/texlive-en.html#x1-320003.4.1>
6. Set the path for the directory of TexLive binaries in your .bashrc file

For 32bit OS

For Bourne-compatible shells such as bash, and using Intel x86 GNU/Linux and a default directory setup as an example, the file to edit might be

```
edit ~/.bashrc file and add following lines
PATH=/usr/local/texlive/2011/bin/i386-linux:$PATH;
export PATH
MANPATH=/usr/local/texlive/2011/texmf/doc/man:$MANPATH;
export MANPATH
INFOPATH=/usr/local/texlive/2011/texmf/doc/info:$INFOPATH;
export INFOPATH
```

For 64bit OS

```
edit ~/.bashrc file and add following lines
PATH=/usr/local/texlive/2011/bin/x86_64-linux:$PATH;
export PATH
MANPATH=/usr/local/texlive/2011/texmf/doc/man:$MANPATH;
export MANPATH
```

```
INFOPATH=/usr/local/texlive/2011/texmf/doc/info:$INFOPATH;  
export INFOPATH
```

Fedora/RedHat/CentOS:

```
sudo yum install texlive  
sudo yum install psutils
```

SUSE:

```
sudo zypper install texlive
```

Debian/Ubuntu:

```
sudo apt-get install texlive texlive-latex-extra  
sudo apt-get install psutils
```

Appendix B

Installing the CUED class file

\LaTeX .cls files can be accessed system-wide when they are placed in the $\langle\text{texmf}\rangle/\text{tex}/\text{latex}$ directory, where $\langle\text{texmf}\rangle$ is the root directory of the user's \TeX installation. On systems that have a local texmf tree ($\langle\text{texmflocal}\rangle$), which may be named “ texmf-local ” or “ localtexmf ”, it may be advisable to install packages in $\langle\text{texmflocal}\rangle$, rather than $\langle\text{texmf}\rangle$ as the contents of the former, unlike that of the latter, are preserved after the \LaTeX system is reinstalled and/or upgraded.

It is recommended that the user create a subdirectory $\langle\text{texmf}\rangle/\text{tex}/\text{latex}/\text{CUED}$ for all CUED related \LaTeX class and package files. On some \LaTeX systems, the directory look-up tables will need to be refreshed after making additions or deletions to the system files. For \TeX Live systems this is accomplished via executing “ texhash ” as root. MikTeX users can run “ initexmf -u ” to accomplish the same thing.

Users not willing or able to install the files system-wide can install them in their personal directories, but will then have to provide the path (full or relative) in addition to the filename when referring to them in \LaTeX .