MONASH University

TRC4000 - Final Year Project

P2P Energy Trading on the Blockchain

Feasibility Report

Semester 1 2021

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Contents

1.0 Introduction

With the recent spike in Cryptocurrencies and Bitcoin's price, it's no surprise that the word 'Blockchain' is something almost everyone with an internet connection has heard of, but what is Blockchain? Blockchain, the record-keeping technology behind the Bitcoin network is a specific type of database that stores data in blocks that are linked (chained) together chronologically. This means that, as new data comes in, it is entered in a fresh block, after the block is filled, it is then linked to the previous block and a new block is created that is ready for new data. Blockchains are able to store several types of information such as names, numbers, and attributes, but their most common use is to store transaction logs [1]. Blockchains are also significantly better than traditional databases in a plethora of ways. Firstly, Blockchain enables trust between network participants due to its decentralized nature that ensures transparency. Secondly, since the possibility of changing any data that is stored on a blockchain without notifying all the peers on the network is almost non-existent, it essentially means that the data integrity is preserved between participants. Last but not least, Blockchains are very resilient to breaches or loss compared to centralized databases, as the data in a Blockchain is stored on all nodes in the network, which makes losing data stored on a blockchain nearly impossible [2].

Due to the disruptive and revolutionary nature of the Blockchain, many industries and enterprise companies have already started implementing their own version of Blockchain with 'real world' benefits and use cases. First of all, Blockchains are enabling faster transactions in the finance industry. The foreign transfer of money may take up to several days to complete, but with the use of blockchain, the receiver can receive the money almost instantly, as the transaction is recorded in the ledger right away. Another 'real world' use case for blockchain would be in land registrations. The land or property can have a list of owners throughout its history, which can all be recorded on a blockchain including its current owner. This combats scams and fraudulent paperwork. Moreover, Blockchain can also be used in the healthcare industry to record the patient's full medical history, drugs he/she has taken before, allergies, and even conditions that have been present in his/her family members. This makes the patient's treatment process much more efficient and productive. Therefore, it is not a question of 'How will the Blockchain affect other industries?' It became a question of 'when?' [3]

Just like Blockchain has affected other sectors, it is about time that it changes the energy sector and becomes an important part of it. With the rise of Microgrids and renewable energy generation through solar panels on roofs, it is only fair that people are allowed to sell and buy this generated energy with ease. Prosumers and consumers can buy and sell to each other through a decentralized peer-2-peer blockchain trading platform that comes with all the features of blockchain integration, starting from its transparent nature up to its high standard security [4]. This report aims to explore the feasibility of such a project and showcase the timeline of events on how it can potentially be implemented, while also shedding light on the risks that would be taken in delivering this project.

2.0 Problem Statement

As the world grows more and more people get access to electricity and have more money to buy bigger houses to live in filled with more appliances and electrical devices, it's only fair that the energy consumption for the average person throughout history has been increasing steadily [5],[6]. Since Grids in Malaysia are supplied with energy through main transmission lines that go from the generators all the way to distribution lines which Then forward that energy to end users such as industrial, commercial, or residential users, it is in no doubt that as this demand and consumption for energy keeps increasing, at one point these transmission lines would have to be upgraded and renewed [7]. This would take a huge amount of time, resources and money, and if nothing is done the transmission lines will be extremely congested during which is already starting to happen now during peak hours.

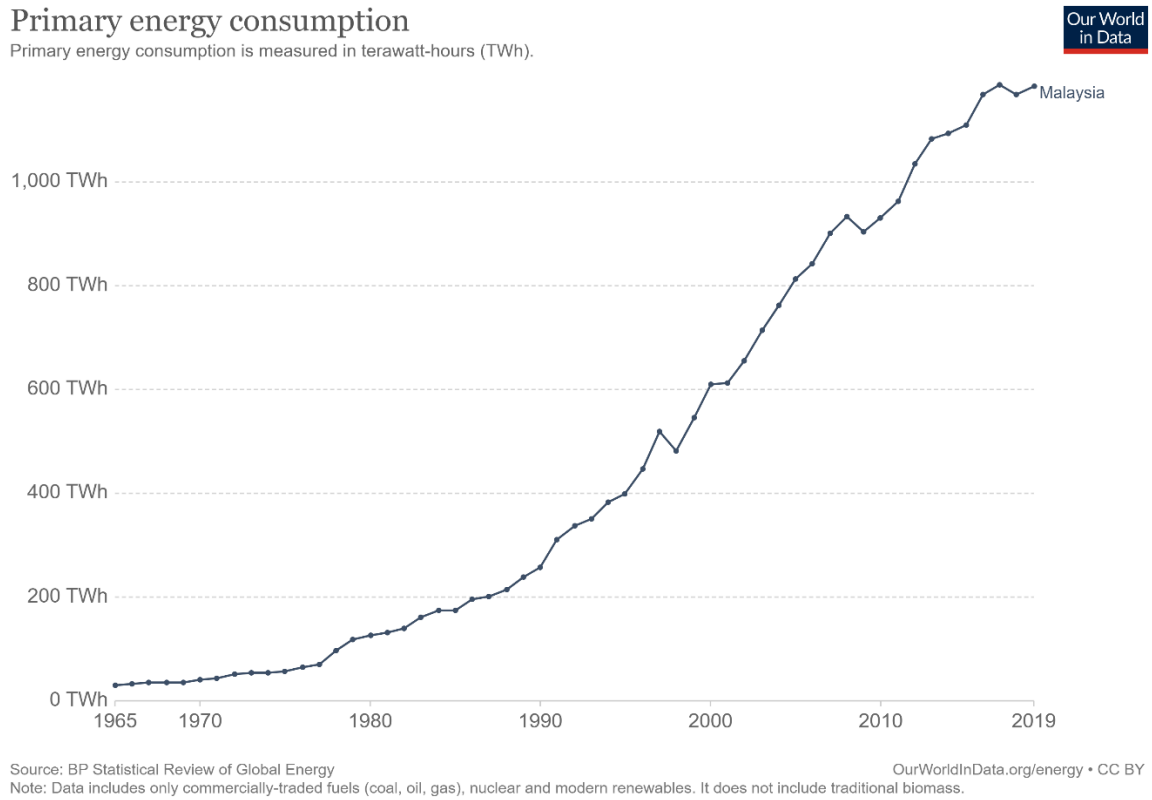

Figure 2-1 Energy consumption in Malaysia over the years [6].

Another downfall of the energy sector according to consumers would be the houses with solar panels who do not own batteries that store their generated surplus of solar energy. They are not benefiting in any way from the surplus energy they generated as all of that energy is dissipated to the grid for free [8]. Not only does that make people feel like they've been cheated on the energy they produced, but also makes them reluctant to use any kind of renewable energy generation in their house.

One way to combat and put an end to the aforementioned problems would be to implement a P2P Energy trading Blockchain platform. Since prosumers would be able to provide surplus energy they generated for sale on the market, consumers would then be able to buy it from them without needing to get electricity from the main transmission lines and

stress them. This would eventually reduce the load on transmission lines as prosumers and consumers are using this P2P environment to facilitate their energy needs and consumption. Consequently, Infrastructure upgrade costs and resources can be invested in another project as this upgrade won't be as necessary as before. Furthermore, an incentive will be created for people to buy their own solar panels at their house so they can start selling on the P2P platform. This will increase the number of people who are using renewable sources of energy, which will eventually lead to a cleaner and greener environment.

Finally, integrating Blockchain in the energy trading environment would be a monumental improvement. It allows the whole market to be decentralized which makes people have more trust in the system as they know that it is not controlled by one single entity[9]. Not to mention that Blockchain enables the use of smart contracts which allows for a more transparent transaction process as the delivery of money and energy is monitored by the computer which minimizes the number of errors made. The use of smart contracts also allows for a more automated trading process among peers[10]. Therefore, it is no surprise that Blockchain could make some huge changes in the energy sector.

3.0 Objectives

This project embarks on the following main objectives:

1- Study about different aspects of the Blockchain technology and Identify areas where research and learning can be done to make sure that clear understanding of the topic is present before starting.
2- Building a fully functioning and secure blockchain platform with authority nodes to approve transactions at acceptable transaction speeds.
3- Develop a fully functioning website and interface where users can trade energy through buy and sell orders with their own accounts and potentially a mobile app with the basic functionality of the website.

4.0 Literature Review

4.1 Origin of Blockchain

Contrary to popular belief, the first time the Blockchain technology was described was by Stuart Haber and W Scott Stornetta in 1991, not by Blockchain founder(s) Satoshi Nakamoto [11]. Later on, in the year 1998, computer scientist Nick Szabo was one of the first people to attempt creating a decentralised digital currency, he called it 'bit gold' [12]. In the year 2008, Satoshi Nakamoto released a white paper detailing a model for Blockchain, following it in the year 2009 by releasing the code for the first Blockchain as the public ledger for the transactions made using Bitcoin [13],[14].

4.2 Types of Blockchain

Blockchain networks have many types depending on the use case, but so far, there are only four major types [15].

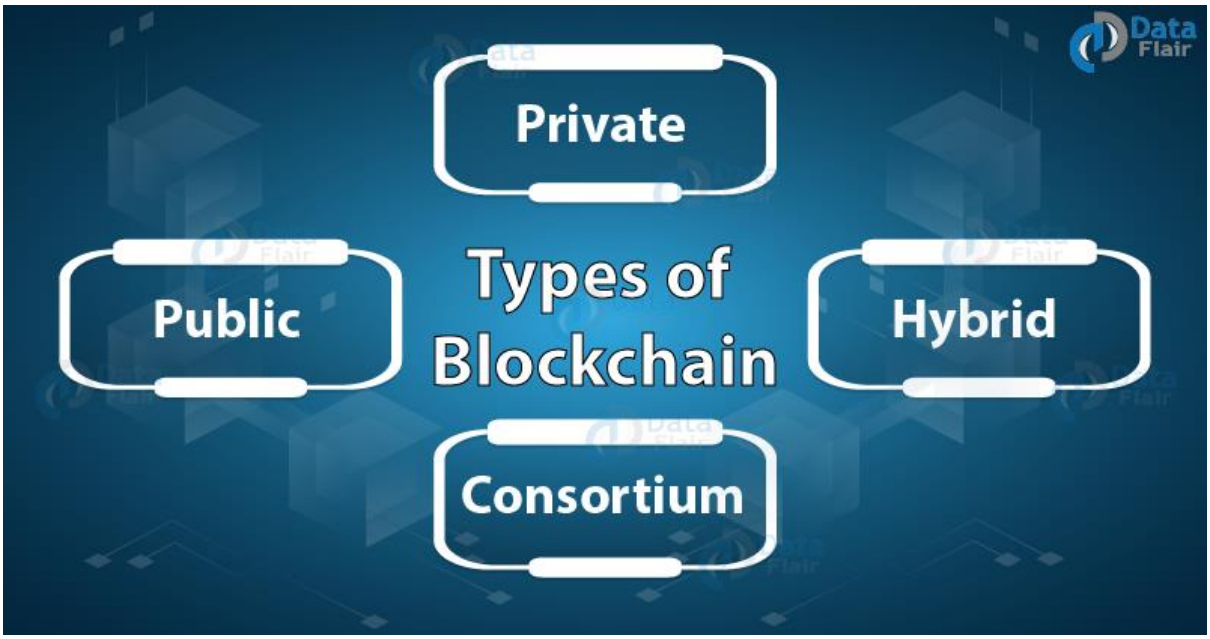

Figure 4-1 Types of a Blockchain network [13]

4.2.1 Public Blockchain

A Public Blockchain is permission-less distributed ledger system with a non-restrictive nature that allows anyone with an internet connection to be an authorized node and a part of the Blockchain network. Public Blockchains are most commonly used for mining and exchanging crypto currencies.

Examples: Bitcoin, Ethereum, and Litecoin.

4.2.2 Private Blockchain

A Private Blockchain is restrictive in nature where users would need a permission from an organization in order to become a part of the network. Private Blockchains are most commonly used within an organization or an enterprise where the members of the Blockchain network are pre-selected.

Examples: Multichain and Hyperledger projects like Fabric.

4.2.3 Consortium Blockchain

A Consortium Blockchain is a semi-decentralized type similar to a private blockchain except that there is more than one organization managing the Blockchain network. Consortium Blockchains are most commonly used in the banking sector and government organizations, etc.

Examples: Energy Web Foundation, R3, etc.

4.2.4 Hybrid Blockchains

A Hybrid Blockchain is a mix of a Private and Public Blockchains where certain blocks are permissionless and can be viewed by anyone, and some other blocks can only be viewed by a select few.

Example: Dragonchain.

4.3 Consensus Mechanisms of a Blockchain

A consensus mechanism in a Blockchain network is a fault-tolerant method used in blockchains to reach the necessary agreement on a single data value or a single state of the Blockchain network [16]. There are large number of consensus mechanism that are used by different Blockchains depending on the use case, but the most common ones are listed below.

4.3.1 Proof of Work (PoW)

Proof of Work is a decentralised consensus mechanism which requires nodes of the network to solve an arbitrary mathematical equation to prevent anybody from cheating the system. It is most commonly used in cryptocurrency mining for validating new transaction registered in the block and mining new tokens [17].

4.3.2 Proof of Stake (PoS)

Proof of Stake is a consensus mechanism where a person can mine or validate a block based on how many coins they hold (their stake); The more stake the person has, the more their mining/validating power increases [18]

4.3.3 Proof of Authority (PoA)

Proof of Authority is a consensus mechanism based on reputation which is usually used in private Blockchains. Block validators are known and pre-approved which means their reputation when verifying transactions is at stake [19].

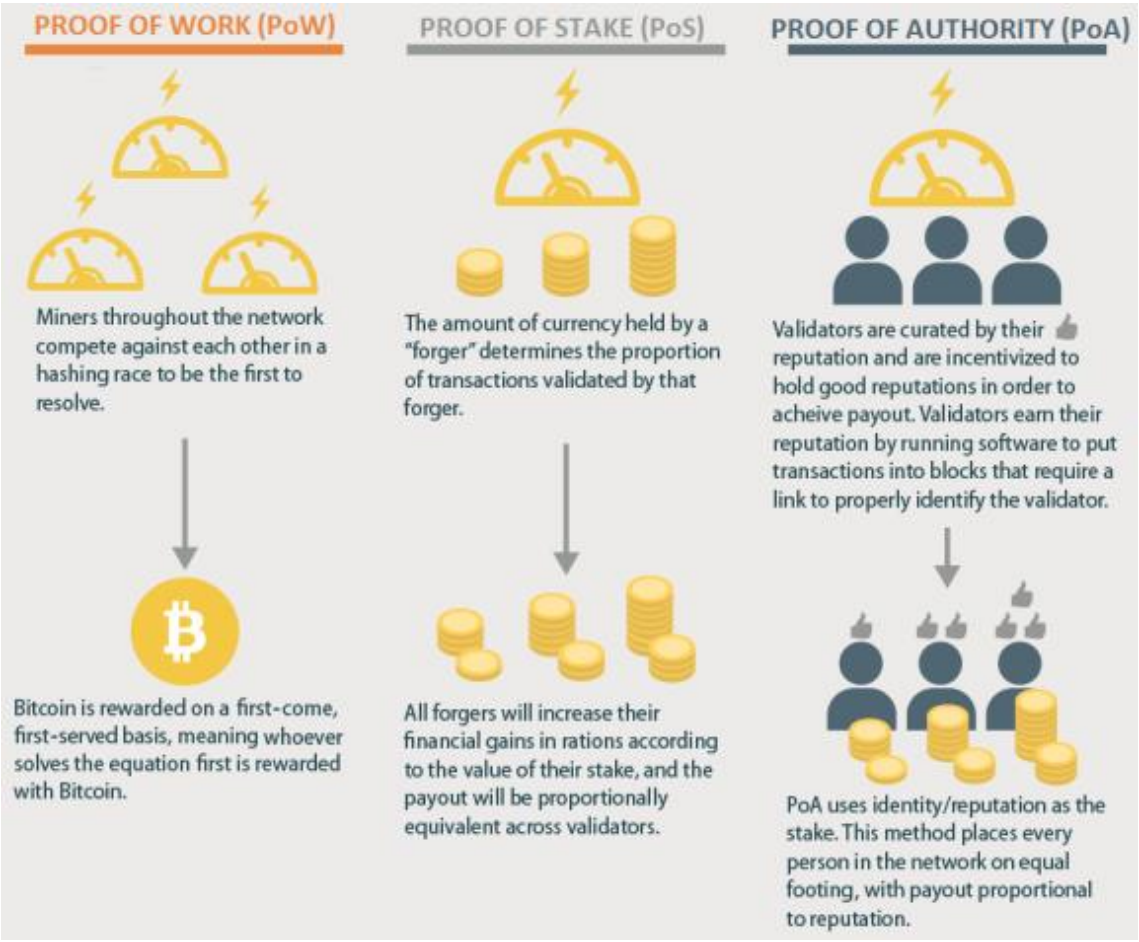

Figure 4-2 Overview of the consensus mechanisms mentioned above [20]

4.4 Previous implementations of a P2P energy trading platform

There has already been multiple research and trials of implementing a P2P energy trading platform/environment in the past with a few who made a huge success in the areas they were deployed in. The International Renewable Energy Agency (IRENA) issued a recent publication in July of 2020 detailing the benefits and possible gains from the implementation of a P2P trading platform [21]. There are many countries now who are currently using a P2P trading platform or at least conducted a pilot test to gauge feasibility. These countries include Germany, Japan, Malaysia, Netherlands, and many more [22].

Existing P2P Energy trading projects:

- Piclo [23]:
    - Established in the UK.
    - The meter data, consumer preference and generator pricing are used to match electricity demand and supply every half an hour.
    - They provide contracts, meter data, billing, good customer service.
- PeerEnergyCloud [24]:
    - Established in Germany.
    - Developed cloud-based technologies for a local energy trading platform for dealing with local excessive production.
    - Provide virtual marketplace for power trading and value-added services within a Microgrid.
- TransActive Grid [23]
    - Located in Brooklyn, US.
    - Provides community energy market that allows members to transact with each other securely and automatically.
    - Current Prototype uses the Ethereum blockchain.

5.0 Methodology

To ensure appropriate progression of the project, a methodological approached has to be devised and checked. This makes the project easier to look at across multiple areas of development and showcases a chronological order of steps taken to complete and finish the project.

5.1 Requirement Analysis & Research

Researching the technology of blockchain and understanding how it works will build strong fundamental knowledge of the project that will be useful throughout the whole project in all of the steps. Not only that, but it will also help in identifying the objectives of SHRDC and TNBX in order to make sure that both parties are aligned in terms of knowledge, thought process and objectives. Learning about the technology will be done by reading research papers made by other people on the topic, taking courses about the topic and going through tutorials of the opensource platforms that are going to be used to build this project.

Requirements made by TNB and SHRDC are the following:

1- Construct the P2P transaction algorithm with the blockchain technology.
2- Develop a mobile app and a website for the platform.
3- Develop servers for the P2P energy trading platform.

5.2 Examining Previous Implementations

Examining previous implementation and research papers of P2P Energy trading on the Blockchain will help establish a clear understanding and overview of the project and will be a vital part in finding the downfalls and challenges of previous implementations so that they will not be repeated [25].

Some of the challenges experienced by previous implementations:

- P2P markets require additional regulations to ensure a fair market for everyone and to define legal boundaries of market users and their eligibility network usage tariffs and taxes [26].
- The difficulty in differentiating between the energy traded and the energy on the grid without the platform users having smart meters [27].
- Lack of incentivisation for users; The energy traded should be sold at competitive prices which would mean that they need to be priced lower than the energy sold by the electric company, so users are inclined to use the platform and actively engage in trading [28].

5.3 Selecting an Opensource platform for Blockchain Development

Building a large scale Blockchain from scratch is a hectic process that may require years to finish which is not suitable for the timespan of two semesters. In order to combat this limitation, an opensource platform will be used to build the blockchain.

Several Blockchain opensource platform exist at the moment such as the ones developed by the Linux Foundation in Hyperledger. Possible platforms to be used are Hyperledger Fabric or Hyperledger Besu [29]. A suitable platform will have to be selected

based on the requirements of the P2P Energy trading application and the requirements of the clients.

The selection will be based upon several criteria like the type of the blockchain (Private-Public-Consortium) and the consensus mechanism used in that specific platform. Moreover, the number of transactions that can be made per second will be valuable metric in selecting the desired platform. Finally, each opensource Blockchain platform is made with a specific programming language which will also have to be taken into account in the selection process.

5.4 Learning to use the selected platform

Regardless of the platform selected, a considerable amount of learning will have to be made in order to use that specific platform. Firstly, if the platform selected is built on an unfamiliar programming language, learning that specific programming language will be valuable when trying to debug the platform or implement new functionality into it. Secondly, going through the documentation of the opensource platform is also very important as it allows for coherent awareness of the environment of the platform and will make the development phase much easier. Thirdly, finishing all the tutorials of the platform if any will give a head start in the development phase and make it much easier as the basic concepts of development would be already tackled. Finally, in the development phase, unseen problems or bugs may occur which will warrant the use of the platforms community and asking them for help on the issue that is being faced.

5.5 Building and Developing the Blockchain Network

After finishing the learning process of the selected platform, the next step is to start developing and building the P2P Energy trading blockchain network running. Firstly, appropriate certification authorities and organizations peers will be made that can oversee the transaction and approve the addition of new blocks. Secondly, smart contracts will be created to automate the transactions made between users and improve the security and validity of the transfers made on the P2P network. Thirdly, creating the ledger where transactions will be stored and new blocks can be added.

5.6 Building a Website and mobile app

When the Blockchain network is initially created, it can only be interacted with through the terminal of the operating system being used. Therefore, an actual interface will need to be created where users would be able to interact with the Blockchain network and the website is able to load the smart contracts and ledger created to be able to write into them and read them. The website should have some basic features with additional room for extra features to be included. Firstly, it should allow users to register a new account which will create a new wallet that will record the transaction that they have made or log in with a username and password of an account that they have made before. Secondly, it should allow the user to place buy/sell orders with the specific amount they are willing to buy/sell and specify the price that they are willing to pay/receive. Thirdly, it should allow the user to select the payment method desired for the transaction to happen and it should be a payment method where a proof of payment can be shown.

Since everyone nowadays owns a smartphone, creating a mobile app that can be accessed with the users' phones will make it much more convenient to them to execute their

transactions at the palm of their hands. It goes without mentioning that the mobile app should be synced with the website and also able to interact and communicate with the blockchain. The mobile app is also not required to have the full functionality of the website, but should at least have the basic functionality of allowing the users to issue buy and sell orders to the market.

5.7 Testing and Validation

After completion of the project, vigorous testing has to be done to ensure that the platform is operating up to the required and needed standard. Firstly, the Blockchain network will need to be verified to check if the transactions are being recorded in the ledger smoothly. Secondly, testing will be done to ensure that the smart contracts implemented are being invoked, executed, and recorded in a correct manner. Thirdly, the website will have to be tested to make sure users are able to log in and register without any issues. It will also have to be tested regarding the transaction time and how fast transactions between two peers are executed.

6 Gantt Chart

P2P Energy Trading on The Blockchain Semester 1

Kareem Osama

Project Start: Mon, 3/1/2021

Display Week: 1

TASK	START	END	DAYS
Phase 1 Requirement Analysis & Research			
Identifying requirements	3/1/21	3/7/21	7
Reading Research papers about Blockchain	3/7/21	3/11/21	5
Taking a blockchain course on edX	3/7/21	3/20/21	14
Examining Previous implementations of P2P Energy trading	3/16/21	3/23/21	8
Setting up a Linux Operating System on my PC	3/14/21	3/16/21	3
Selecting an Open Source Platform for Blockchain Development			
Research on HyperLedger as an overall platform	3/18/21	3/22/21	5
Research on HyperLedger Besu	3/20/21	3/25/21	6
Research on HyperLedger Fabric	3/22/21	3/27/21	6
Comparing between the shortlisted platforms	3/27/21	3/28/21	2
Selecting the final platform to be used	3/28/21	3/29/21	2
Learning to use the selected platform			
Intsalling the platform on my computer	3/29/21	3/29/21	1
Running through the getting started tutorials	3/30/21	4/5/21	7
Running through the main tutorials	4/11/21	4/24/21	14
Build and Develop the Blockchain Network			
Create appropriate Certification Authorities and Organisations	4/24/21	5/3/21	10
Creating and designing the Smart Contracts	5/2/21	5/12/21	11
Creating the ledger where transaction can be made	5/12/21	5/22/21	11
Testing the Blockchain Network	5/22/21	5/29/21	8
Project Submissions			
Project Registration	4/16/21	4/16/21	1
Feasibility Report	4/8/21	4/16/21	9
Progress Presentation Video	5/15/21	5/25/21	11
Student Reflection/Logbook	3/1/21	11/6/21	251

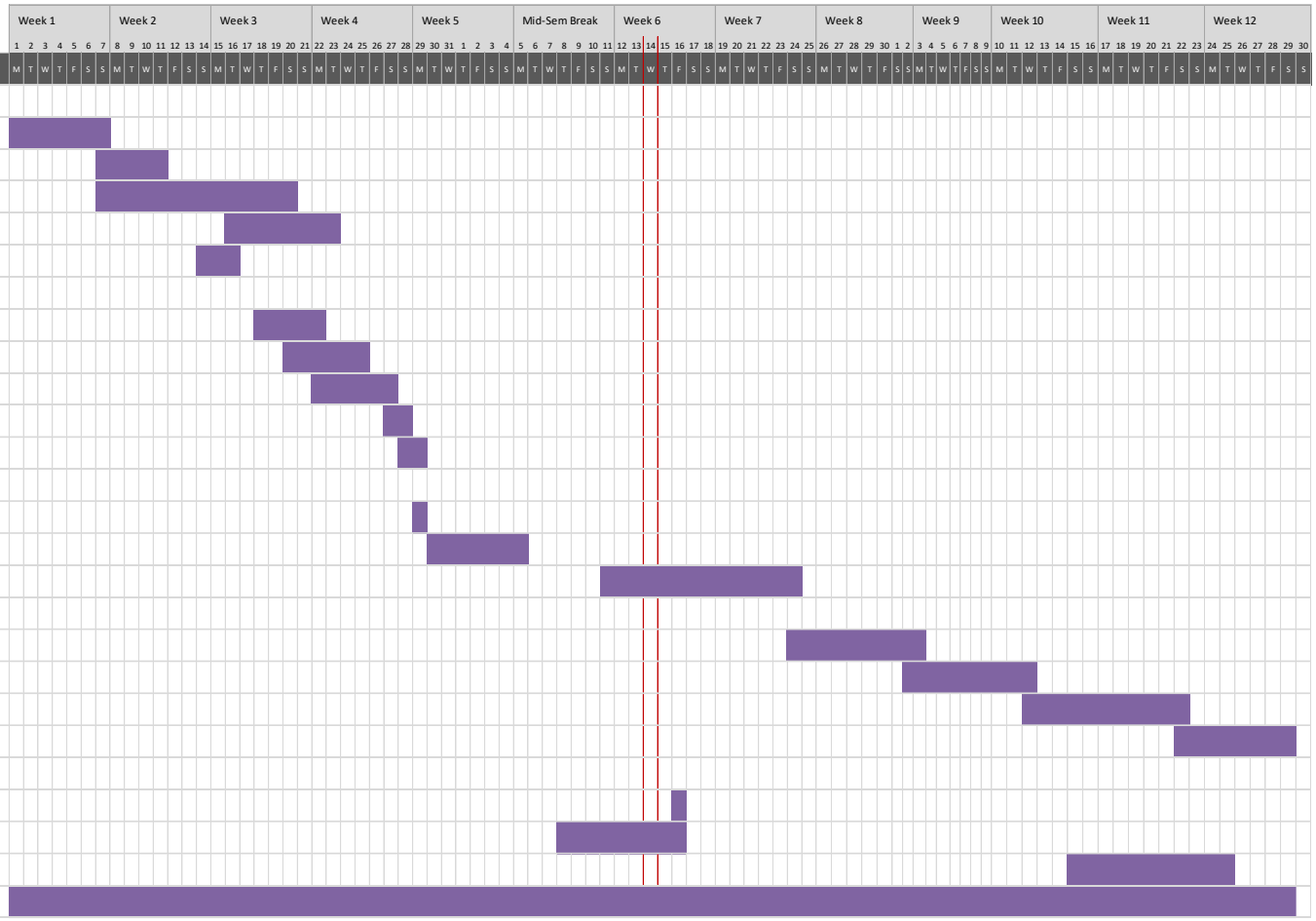

Figure 6-1 Gantt chart Semester 1

P2P Energy Trading on The Blockchain Semester 2

Kareem Osama

Project Start: Mon, 8/2/2021

Display Week: 1

TASK	START	END	DAYS
Building Website			
Identifying requirements for the website	8/2/21	8/8/21	7
Check supported languages for integration	8/8/21	8/11/21	4
Developing Backend of the website	8/8/21	8/26/21	19
Devoloping Frontend of the website	8/22/21	9/8/21	18
Building Mobile Application			
Identifying requirements for the app	9/8/21	9/14/21	7
check supported languages for integration	9/10/21	9/13/21	4
Developing Backend of the app	9/13/21	9/28/21	16
Developing Frontend of the app	9/21/21	10/6/21	16
Integration and Synchronisation			
Making Sure Website is fully able to interact with the Blockchain	9/8/21	9/14/21	7
Making sure smart contracts are invoked correctly	9/15/21	9/19/21	5
ensure synchronisation between app and website	10/6/21	10/10/21	5
Tesing and Validation			
Testing full functionality of the website	10/10/21	10/15/21	6
Testing full functionality of the app	10/12/21	10/17/21	6
Testing the transaction rate per second	10/17/21	10/23/21	7
Testing the creation of new blocks	10/19/21	10/24/21	6
Project Submissions			
Final Report Draft	10/11/21	10/18/21	8
Research Paper	9/22/21	10/22/21	31
Final Seminar Presentation and Demo Videos	9/22/21	10/24/21	33
Final Report	9/15/21	10/25/21	41
Student Reflection/Logbook	3/1/21	11/6/21	251

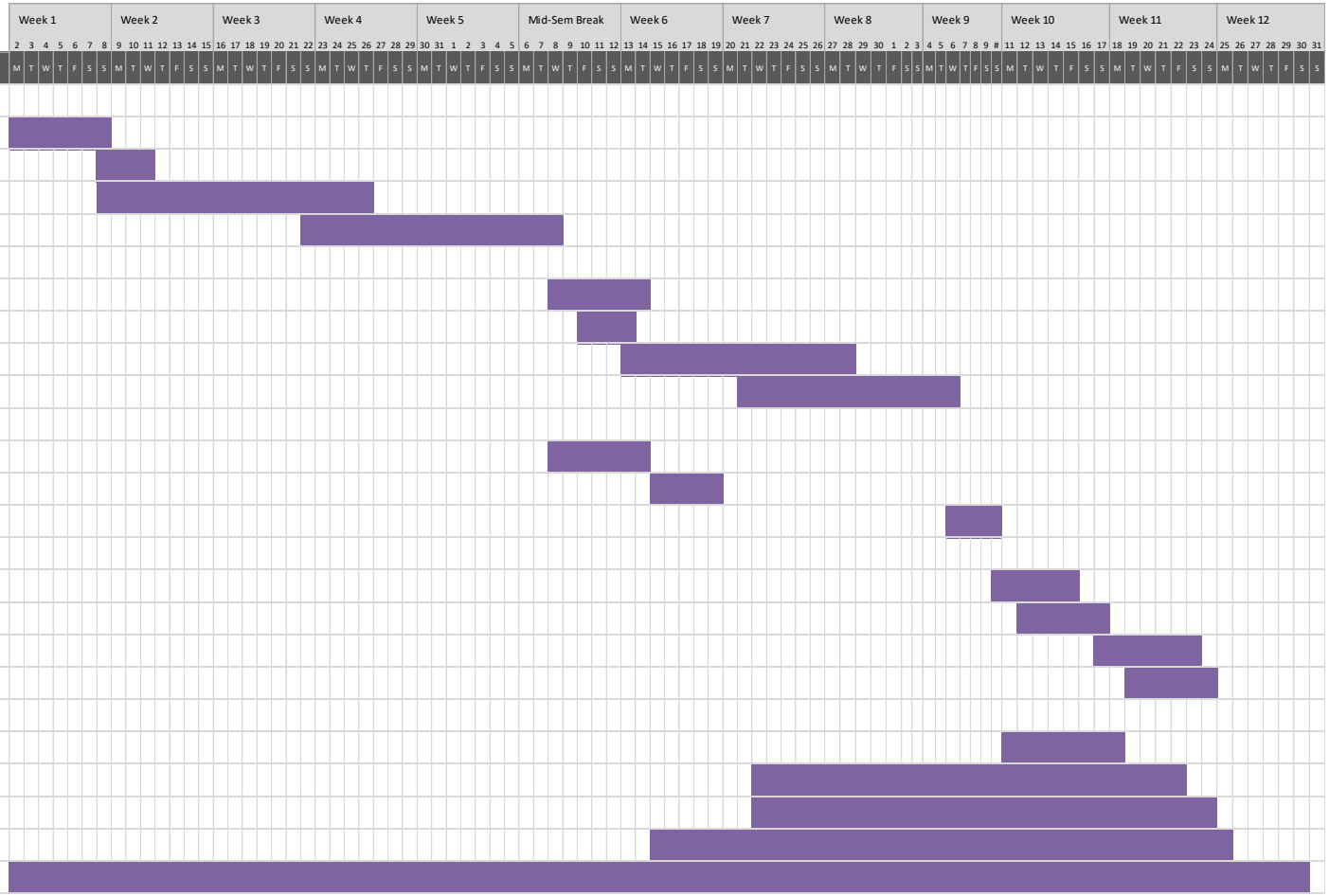

Figure 6-2 Gantt Chart Semester

7 Risk Assessment

No.	Risk Item	Effect	Cause	Impact	Probability	Action to Mitigate Risk
1	Project more complex than anticipated	-Poor progress -Delivering Sub-par Results	-Unrealistic Expectations -Poor Time management	High	Low/Medium	-Communicating with the Supervisor to take appropriate action -Planning ahead of time and breaking down tasks into smaller achievable chunks
2	Skills not sufficient for task	-Tasks taking longer to complete -Delay the Whole Project	-Limited knowledge and experience on the topics	Medium/high	Medium/High	-Plan project with regards to lack of experience -Learning while completing the project
3	Does not meet the requirements of the client	-Client not satisfied with the proposed solution	-Requirements were not Understood or communicated properly	High	Low	-Keep the client up to date with the progress and involve them in the development process
4	Scaling of Project is too Expensive	-Difficulty in deploying the project in a pilot test	-Blockchain being a new technology with low competition, so prices can be expensive	Medium/High	Low/Medium	-Do enough research about the costs of such scaling -Use opensource whenever Possible to minimize costs
5	System did not function as expected after integration	-Difficulty in achieving project objectives and fulfilling requirements	-Incompatibility of 2 sub-systems with one another -Mistakes in the development phase -Bugs present in the code	High	Medium	-Ensure Subsystems are compatible with one another before integration -Double check all subsystems before integrations for errors and mistakes -Research Bug fixes if any bugs arise in the project
6	Tasks not distributed reasonably over the	-Slow Progress -Increased Stress	-Poor project Management	Low/Medium	Low/Medium	-Consult Supervisor about work distribution

	span of two semesters	-Failure to deliver a high-quality Project				-Use work distribution methods like Gantt charts and Work breakdown structures
7	Loss of all Data	-Losing All progress -Starting from scratch on the Project	-Malware or Viruses -Hard disk malfunctions or dies	High	Low	-Make Periodical Backups to the Project -Host the Project on a cloud-based server to mitigate data loss

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