Free market blockchain P2P energy trading

PROJECT PLAN

Team #41

Arun Sondhi: Hardware/software API

Alec Dorenkamp: Smart contract / blockchain design

Noah Eigenfeld: Smart contract / blockchain design

Brendon Geils: Blockchain and API development

Jack Myers: Smart meter circuit design

Joe Staudacher: Power sensing/hardware

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Contents

1 Introduction

1.1 Project statement

Our project has two major components: the development of an inexpensive and user friendly smart power meter and software to facilitate peer to peer trading of surplus energy. When these two stages of the project are complete, individuals using our hardware and software will be able to buy or sell surplus energy at significantly better rates than could be obtained going through a utility company.

By allowing homes and businesses to effectively trade energy in a free market environment it will create an opportunity for individuals to think broader on how they produce and consume energy. By creating a free market there is an incentive to over-produce energy to sell back to the grid until the utility cost is at parity with the market value.

A home or business will buy solar or other forms of energy generation to supply the market demand. This allows the market to be decentralized as the energy production will be spread out over the homes instead of the bulk being produced through the utility.

1.2 Purpose

On a large scale, our project is targeting one of the most significant problems that is affecting the world right now: climate change. Renewable energy usage is seen as one of the key ways to target this problem, but a large portion of worldwide energy does not come from this "clean" energy generation. With our project, we hope to incentivize the generation of renewable energy and make it more accessible to individuals and businesses, rather than only those who have the resources and capabilities of a large energy company.

On top of incentivizing clean renewable energy the end solution would tend to decentralize the power generation market. By reducing the power generation of the utility company there is a reduction of blackout possibility. Even though we live in a society that has seen blackouts far and few in between this is because of the interconnectedness of grids. A Chicago grid can pull from a Toronto plant if they approach their capacity curve. A more decentralized grid would reduce this thereby reducing power losses and surcharges.

The power loss to move energy a mile up the road will be less than the cost to move that energy from Toronto to Chicago.

1.3 Goals

We anticipate that this project, in the long run, has the potential to be implemented in a large scale. Taking into account the time and resource constraints associated with this project, our goal is

to have a working prototype that can be tested first on a preliminary level and potentially on a network of 400 homes.

A stretch goal for the project would be to develop a marketplace where these peer to peer interactions could be facilitated. We would have to find a way to automate this process so users would simply have to say how much power they need at what times and the system would arrange for that transaction to take place.

In addition to our goals related to the application of our solution, we also have some goals throughout the process of developing our solution. We hope that this design process will be a beneficial experience for us, aiding us in learning how to interact with contacts in industry and respond to their feedback in order to tailor our work to most effectively solve the problem at hand.

2 Deliverables

Blockchain Implementation

Power transactions will be made and recorded using a blockchain implemented on Ethereum's platform. This blockchain will be the backbone of our project, as it will keep a ledger of all power transactions that occur in a network of users. The decentralized-ledger approach of a blockchain will ensure all transactions are trustworthy, even though users may remain completely anonymous. The blockchain will consist of a set of smart contracts in Ethereum defining our own cryptocurrency for power transactions, and logic to initiate and accept transactions.

IOT Smart Meter

An internet of things smart meter will need to be installed at a user's property to control the flow of power from that user to their power supplier. This smart meter will be connected to the internet, and will interact with the blockchain to physically enact transactions. The smart meter will be able to send/receive power over set periods of time, which will be set during a transaction. For this project, we will develop a working prototype that is able to send and receive power, and communicate with our blockchain to enact transactions.

Web Application

Users will manage their power transactions through a simple web application, which will interact with our blockchain. Since the focus of our project is on the blockchain and smart meter implementations, this application will provide only the basic functionality needed for users to track and trade their power. Such functions include login/account creation capability, viewing transaction history, and initiating/accepting transactions. In the future, this web application may be expanded to better meet the needs of the customers.

3 Design

Software

1. Ethereum Approach

Using the open-source ethereum (blockchain) platform to develop our smart contract for buying and selling assets (energy). Using ethereum we can utilize their stable Solidity language to implement our smart contract. The advantage here is there are many projects built with this stack allowing for more resources and support.

2. Hyperledger Approach

Using the open-source hyperledger (blockchain) platform which is newer compared to the tried and true ethereum approach. Hyperledger is supported by larger organizations such as IBM. We believe this will allow the technology to stabilize long term with the backing of a large company compared to the burn-out many open-source projects that lack an organization have seen.

Hardware

1. Arduino + Wifi Shield Approach

Using GPIO to continuously calculate available energy and control the power management system. The data will then be used for buying and selling. A wifi enabled shield will provide IoT capabilities to support transactions.

The arduino will be linked to a two-way meter and work as a smart meter. Current and power usage will be tracked and data will be transmitted to the marketplace.

2. Microcontroller/custom PCB Approach

Functionally identical to the arduino approach, only the built from a different set of components. Both will record and send data for buying and selling.

3.1 Previous work/literature

Previous work has been done by pwr.company an organization that prototyped the energy blockchain software. Their github repo shows the current strategy for buying and selling a utility such as energy.

In 2016 there was a blockchain energy implementation in New York City, specifically the Brooklyn borough. Two companies LO3 Energy and Consensys teamed up to form TransActive Grid. The pair

wired up two Brooklyn residences and traded energy on the blockchain. The details of this transaction were left out due to IP implications from the organization.

3.2 Proposed System Block diagram

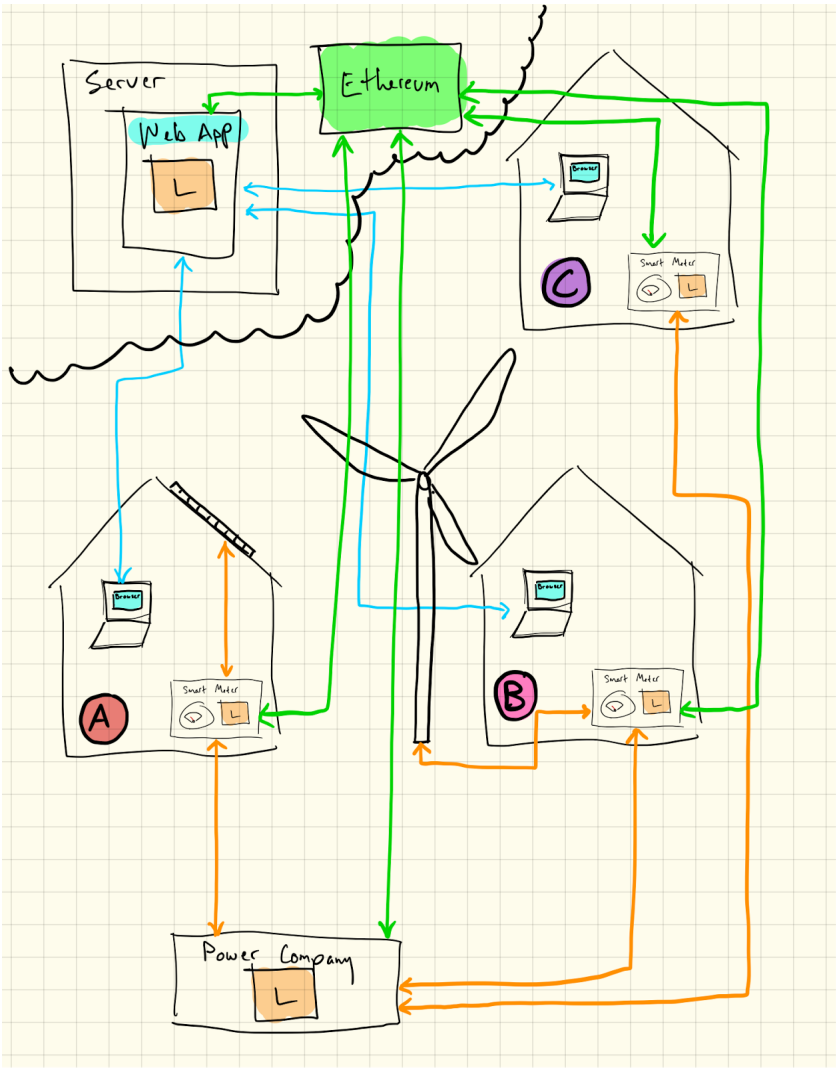


Figure 1: A rough diagram of our proposed system. Each property will use a smart power meter to control the flow of power from the property (and any power-generating devices, such as solar panels or wind turbines) to their power company. Each smart meter will be linked to the blockchain via an internet connection, and will have a copy of the transaction ledger. A user for any given property may access the ledger and their transactions through a web application, which we will design. All power is passed through the power company for any given transaction.

3.3 Assessment of Proposed Methods

It is to be determined which approach we will follow for the blockchain software, which will make up a sizable portion of the time and effort put into this project. We will have to weigh the stability and previous usage of Ethereum against the potential benefits of a newer platform that had the opportunity to learn from the mistakes of its predecessors. In the end, our decision will come down to what will be the most useful in the long run, both for our team of developers and individuals who could potentially work on this project in the future.

As the project progresses, we will have to work to narrow down the scope of the project. The problem that we are attempting to tackle is far too large to handle in this amount of time or this number of people. At this point, we anticipate that our approach will be to focus on the core functionality that is required for a proof of concept. There are many long term goals for this project that would be need to be met if our solution is to be implemented on a large scale such as: power equipment for this distribution, interfacing with the existing system used by the power company, and refining an open marketplace for energy transactions. Realistically, the approach that we want to follow will be to aim for the fundamentals that would allow us to test if our system would be feasible in reality, and then follow up with the rest when the time comes.

There are numerous options currently available on the market for smart meters, and with them, various design approaches that are followed. While it would be possible for us to built our own from the ground up, it is likely that it will be easier to avoid “reinventing the wheel” and use some type of device with basic functionality built in like an Arduino or a Raspberry Pi. While this approach would allow us slightly less flexibility in the exact layout of our hardware, it would allow us to dedicate more time to polishing the smart meter and the interface between it and the software side of our project.

3.4 Validation

The simplest way for us to confirm that our solution works is testing it. Because our project is broken into two parts (smart meter and blockchain software), there will be multiple stages of testing. We will test the functionality of the smart meter to determine that it is able to serve as an accurate and non-intrusive method of reading power input to a house. Concurrently, we will be testing the functionality of the software to make sure we can reliably and securely process transactions. When the unit testing stages are completed, we will move on to integration testing to make sure the entire system works together cohesively. If we have the opportunity, it could also be beneficial to work on testing in a system with a large number of points (houses) to make sure that everything is scalable.

4 Project Requirements/Specifications

4.1 Functional

Though this project will be difficult, the requirements are rather simple. The requirements will include:

1. A blockchain software implementation
2. An IoT Smart Meter device
3. Web app for management of transactions
4. API for communication between the smart meter and the blockchain

The requirements could grow and change as progress is made but these requirements are the core of the project and will dictate our goals over the coming months.

4.2 Non-Functional

The project must meet certain standards that we as a group agree on. We want the platform for the blockchain to be robust and have the ability to expand on it if desired. Our goal is to end up with a product that we can be proud of and have it be something that we are eager to present to the client. Each group member will strive to put their best work forward and each contribute their own unique values to the project.

4.3 Standards

Project development will follow a structured model for Git version control. We will use pull requests that'll require at least one other member's approval. Each task will have it's own branch and those branches will be appropriately named based on their task. All commits will have will have sufficiently descriptive comments. All code will include descriptive objects and class names. Each method and class will be sufficiently commented except obvious getters and setters.

5 Challenges

1. Most blockchains, especially with cryptocurrencies, deal with instant transactions, unlike sending electricity. The problem we face is figuring out a way to prevent either side from scamming the other while the energy is being sent.
2. Does a user have to put energy into the system at the same rate that it is being consumed? Will there be any timing issues? More research still needs to be done.

3. We will need to figure out the optimal way to connect the IoT device to the Blockchain.
4. None of the group members have ever worked on a blockchain system, so the lack of experience could be a potential problem.

6 Timeline

6.1 First Semester

Class Deliverables

1. Project Plan
2. Design Document
3. Team Website

Hardware Team (Jack, Joe, Arun)

1. Research pars and determine platform to be used
2. Create tentative parts list with pricing
3. Finalize parts list

Software Team (Brendon, Noah, Alec, Arun)

1. Experiment with Ethereum and creating smart contracts
2. Web app user interface mockups
3. Component diagram for web app
4. Component diagram for blockchain implementation
5. Component diagram for smart meter API

6.2 Second Semester

Class Deliverables

1. Working prototype smart meter
2. Basic functional web application
3. Working blockchain cryptocoin implementation
4. All components successfully interact

Hardware Team (Jack, Joe, Arun)

1. Create board prototype and order it
2. Program data acquisition and transmission capabilities
3. Program user interface

Software Team (Brendon, Noah, Alec, Arun)

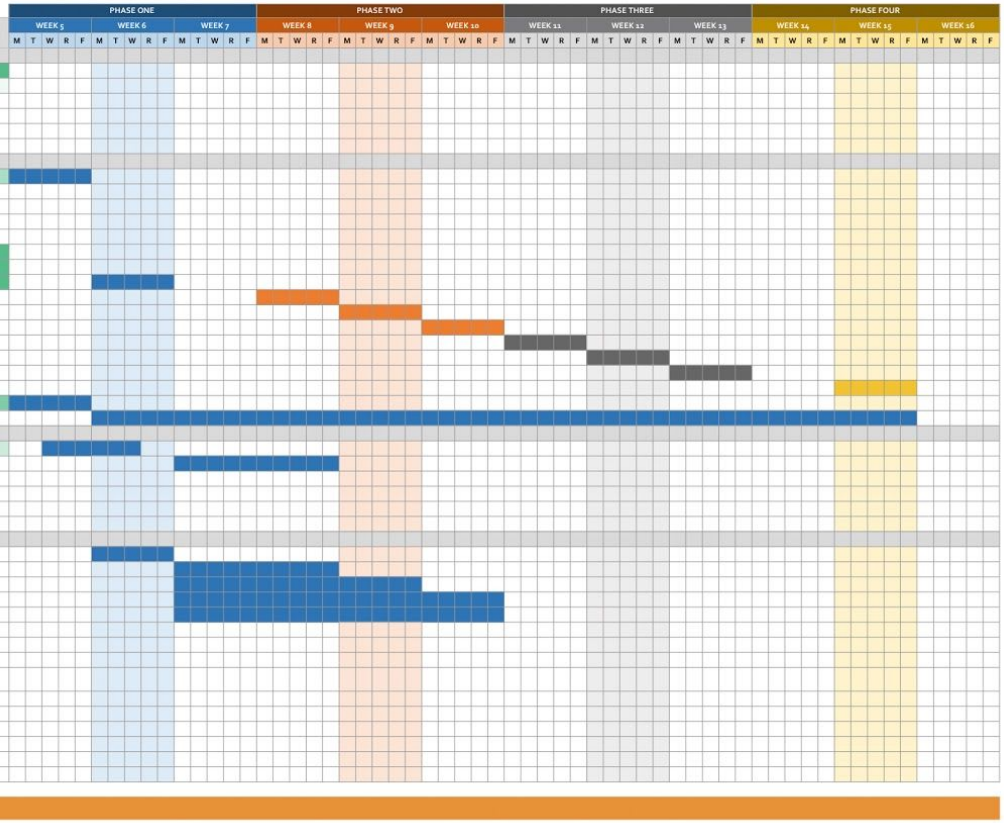
1. Smart contract defining cryptocoin on Ethereum
2. Smart contract for initiating a transaction
3. Smart contract for accepting a transaction
4. API components for communicating between blockchain and smart meter

5. Create account functionality through web app
6. Login functionality through web app
7. View transaction history functionality through web app
8. Initiate and accept transaction functionality through web app

GANTT CHART

PROJECT TITLE	Energy P2P trading with blockchain	TEAM MEMBERS	Jack Myers, Brendon Geils, Arun Sondhi, Noah Eigenfeld, Alec Dorenkamp, Joe Staudacher
PROJECT ADVISER	Goce Trajcevski	DATE	9/24/17

TASK NUMBER	TASK TITLE	TASK OWNER	START DATE	DUE DATE	DURATION	PCT OF TASK COMPLETE
1	Overall project planning					
1.1	Project overview	Brendon	9/4/17	9/8/17	4	100%
1.2	Develop specific task list and delegate	All	9/25/17	10/6/17	11	10%
1.3					0	0%
1.4					0	0%
1.5					0	0%
1.6					0	0%
2	Class deliverables					
2.1	Project plan v1	All	9/18/17	9/22/17	4	50%
2.1.2	Project plan v2	All	9/25/17	10/27/17	32	0%
2.1.3	Final project plan	All	10/30/17	12/1/17	31	0%
2.2	Design document v1	All	9/25/17	10/6/17	11	0%
2.2.1	Final design document	All	10/9/17	12/8/17	59	0%
2.3	Weekly progress report 1	Jack	9/4/17	9/8/17	4	100%
2.3.1	Weekly progress report 2	Joe	9/11/17	9/15/17	4	100%
2.3.2	Weekly progress report 3	Noah	9/25/17	9/29/17	4	100%
2.3.3	Weekly progress report 4	Alec	10/9/17	10/13/17	4	0%
2.3.4	Weekly progress report 5	Brendon	10/16/17	10/20/17	4	0%
2.3.5	Weekly progress report 6	Arun	10/23/17	10/27/17	4	0%
2.3.6	Weekly progress report 7	Jack	10/30/17	11/3/17	3	0%
2.3.7	Weekly progress report 8	Joe	11/6/17	11/10/17	4	0%
2.3.8	Weekly progress report 9	Alec	11/13/17	11/17/17	4	0%
2.3.9	Weekly progress report 10	Noah	11/27/17	12/1/17	4	0%
2.4	Team website v1	Arun	9/18/17	9/22/17	4	75%
2.4.1	Final team website	Arun	9/25/17	12/8/17	73	0%
3	Hardware (smart meter) tasks					
3.1	Research parts/determine platform to be used	Jack, Joe	9/20/17	9/27/17	7	30%
3.2	Create tentative parts list with pricing	Jack, Joe	10/2/17	10/13/17	11	0%
3.3	Finalize parts list	Jack, Joe			0	0%
3.4	Create board prototype and order it	Jack, Joe			0	0%
3.5	Program data acquisition and transmission capabilities	Jack, Joe, Arun			0	0%
3.6	Program user interface	Jack, Joe, Arun			0	0%
4	Software tasks					
4.1	Experiment: Creating Ethereum smart contracts	Noah, Alec	9/25/17	10/2/17	7	0%
4.2	Web App UI Mockups	Noah, Alec, Brendon	10/2/17	10/9/17	7	0%
4.3.0	Component Diagram: Web App	Noah, Alec	10/2/17	10/16/17	14	0%
4.3.1	Component Diagram: Blockchain	Noah, Alec, Brendon	10/2/17	10/23/17	21	0%
4.3.2	Component Diagram: Smart Meter	Noah, Alec, Arun	10/2/17	10/23/17	21	0%
4.4.0	Program Blockchain: Coin definition	Noah, Alec, Brendon			0	0%
4.4.1	Program Blockchain: Initiate transaction	Noah, Alec, Brendon			0	0%
4.4.2	Program Blockchain: Accept transaction	Noah, Alec, Brendon			0	0%
4.5	Blockchain/Smart Meter API: Signal Send/Recieve Power	Noah, Alec, Brendon, Arun			0	0%
4.6.0	Program Web App: Create Account/Register Smart Meter	Noah, Alec			0	0%
4.6.1	Program Web App: Login	Noah, Alec			0	0%
4.6.2	Program Web App: View Transaction History/Ledger	Noah, Alec			0	0%
4.6.3	Program Web App: Initiate Transaction	Noah, Alec			0	0%
4.6.4	Program Web App: Accept Transaction	Noah, Alec			0	0%
4.7					0	0%



7 Conclusions

If we complete our goals, our project has the potential to have important implications on the future of the energy market. We believe that with our team, we can make this project reach its full potential. By the end of the second semester of the project, we hope to have a functional prototype that we can use as a proof of concept in order to gain the traction to apply our solution at a large scale. Between the smart meter and blockchain free market trading software, all of the vital components will be present to show the benefits that this approach to distributing surplus energy has over the existing methodology.

8 References

List all the sources you used in understanding your project statement, defining your goals and your system design. This report will help you collect all the useful sources together so you can go back and use them when you need them.

http://pwr.company/

https://github.com/bgeils/pwr-blockchain/

https://www.bitfinex.com/

http://gridsingularity.com/

http://www.solarcity.com/sites/default/files/SolarCity_Distributed_Grid-021016.pdf

https://www.fastcompany.com/3058201/this-new-york-project-fuses-energy-microgrids-with-blockchain-technology

9 Appendices

If you have any large graphs, tables, or similar that does not directly pertain to the problem but helps support it, include that here. You may also include your Gantt chart over here.