Imperial College London

Department of Electrical and Electronic Engineering

Final Year Project Report 2015

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Acknowledgements

I would like to thank my supervisor Dr Jeremy Pitt for taking the time to impart advice, guidance and supervision over the past academic year on this project.
I would like to thank e.quinox, all members past, present for giving me the opportunity of a lifetime and giving me the information to make this project relevant.
I would also like to thank my friends, housemates and fellow colleagues who have made my last 4 years the best experience it could possibly be.
Finally, I would like to thank my family, in particular my mother for their support and love.

Yuchen Wang
June 2015

Abstract

In many developing countries the electricity grid network is underdeveloped, causing low levels of rural electrification. However, electricity access in these rural communities are not non-existent. There exists a number isolated and independent electricity generators owned by individuals, NGOs and local government institutions. This project aims to explore the feasibility of a Decentralised Community Energy System which utilises these isolated sources of electricity to better serve communities with a micro grid.

Using a holonic system, collectives of energy providers can be modelled using a Multi-Agent System to pool electricity as a Common Pool Resource. Similarly, electricity allocations can be distributed fairly using holonic institutions and Rescher's Canons of Distributive Justice to guarantee all consumers a continuous access to electricity.

This project applies these principles to create a simulator for Decentralised Community Energy Systems, and demonstrates the feasibility of a community micro grid.

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Introduction 1

Electricity is in wide-spread use in many developed countries and are delivered by a vast network of cables, overhead lines and other assets maintained by Distribution and Transmission Network Operators. Electricity access has 100% penetration in the UK,[2] and residents also benefits from a Transmission Network which operates at above 99% reliability.[3] In many areas of rural developing countries, there are often no wide-spread access to a continuous and reliable electricity supply which is provided by the country's electricity grid.[4] However there exists many isolated sources of electricity generation such as solar panels and standalone diesel generators utilised by relatively wealthy households, shops and buildings belonging to large organisations.

The aim of this project is to explore the idea of using a holonic institution to model a Decentralised Community Energy System which bring together the existing decentralised generation infrastructure to provide a reliable electricity for users in rural communities. The model was constructed as a Multi-Agent System (MAS) and simulated using Presage 2 with individual consumers such as households and providers such as generators modelled agents. The agents can be grouped together to form communities such as villages, which in turn can be grouped together to form a larger entity such as a district or a province.

With the vast majority of people living in communities such as villages, towns and cities, the structure of the decentralised energy system model will need to be designed in a fashion that is scalable and allows grouping of people to form communities. In a traditional electricity system operated by most developed countries is composed of centralised generation, transported around the country by transmission systems and distributed to consumers by the distribution network. Traditional models and structures do not apply to this project as they have been designed for mostly uni-directional power flow: from large generators to consumers. With many of the users of the Decentralised Community Energy System capable of both consuming and generating, a scalable micro-grid for this model needs to be designed with that in mind.

Designing the structure of the simulation on the design of holonic systems simplifies the scalability aspect of having multiple communities in a simulation. A holonic system is one which is formed of many smaller systems, which are in turn formed of many smaller systems and so on, until reaching the most "elementary" of systems. In the case of this project, the simulation will be designed to be able to distribute fairly electrical power between interrelated agents which are in turn composed of interrelated subagents recursively, until reaching lowest level of subagents (households and businesses).

A Multi-Agent System was selected to simulate as Agents are required to be able to act independently, to be unable to directly manipulate the environment and unable to control the actions of other Agents. In the case of this simulator, consumers are independent entities who can't change the environment conditions (e.g. have access to Grid Electricity) and unable to directly control the consumption and provision of other consumers or providers. Presage 2 was selected as the Multi-Agent Simulation platform as it was possible to seek support from PhD students within the EEE department who currently use the system.

With Presage 2, there are also some issues and limitations. The simulation results can sometimes be inconsistent due to out of order parallel execution by the simulation platform, and the simulation can only execute in discrete time steps. Suitable design steps have been taken to mitigate these problems and limitations which have been detailed in the Design section of this report.

To allow the model to be realistic, the model has been based on real rural communities in Rwanda, with realistic demand and generation profiles. Due to the lack of available data in Rwanda, the demand and generation profile has been approximated using data from rural UK load centres.

This report outlines the design, implementation and testing of a holonic multiagent simulation of a decentralised energy system.

Background 2

Electricity as a Common Pool Resource

A Common Pool Resource is a depletable resource which can be utilised by a group of people, characterised by a reduction in the availability of this resource as individuals withdraw or utilise this resource.[5] Electricity can be a Common Pool Resource if there exists a finite amount of electricity generation capacity. As users connect demand appliances to the generators, the availability of electricity supply for additional demand diminishes.

In developing communities with significant generation from renewable sources such as wind and solar, the availability of power is subject to variation between periods in time. This inherent volatility in the amount of available resource could increase the likelihood of selfish actions of by individuals in the community.

Ostrom showed that Common Property Regimes can be formed to maintain the Common Pool Resources by controlling the access to the resource.[5]

Decentralised Community Energy Systems as a Holonic System

A holonic system (or holarchy) is a system which is composed of interrelated subsystems or institution, each of which are in turn composed of sub-subsystems or institution and so on, recursively until reaching a lowest level of "elementary" subsystems. Each system, sub-system or institution has a well-defined set of goals or objectives which is achieved through enforcing a set of rules on its members (subsystems, sub-institutions and elementary entities).[6] It is this type of Common Property Regime that will be explored in this project to maintain the Common Pool Resource that is electricity.

In the context of a rural Decentralised Community Energy system, a network between households, communities and even villages to pool and share electricity as a common pool resource can be modelled as a holonic system. The holonic system in this case would be composed of communities such as Districts, Provinces, Sectors which are composed of sub-communities such as Towns and Villages. The sub-communities would be composed of many "elementary" subsystems such as households, businesses and other points of connection for electricity. Each community or institution has the goal of fairly allocating electricity to all members. This goal would be achieved with the assumption that they are provided with the necessary infrastructure and powers for enforcing quotas and contribute to a common pool of electricity.

Ostrom's principles

Distributive Justice and Fair Allocation

Given that the necessary infrastructure and powers exist for enforcing quotas and contribution to the Common Pool, the allocation needs to be fair. Being fair forms two of the necessary Ostrom's Principles for Enduring Institutions in a Common Property Regime.[5]

Rescher's Canon of Distributive Justice

Multi-Agent Simulation

The simulation will be designed as a Multi-Agent System (MAS). MASes are particularly suited for this kind of model as Agents in MASes have three very important characteristics:

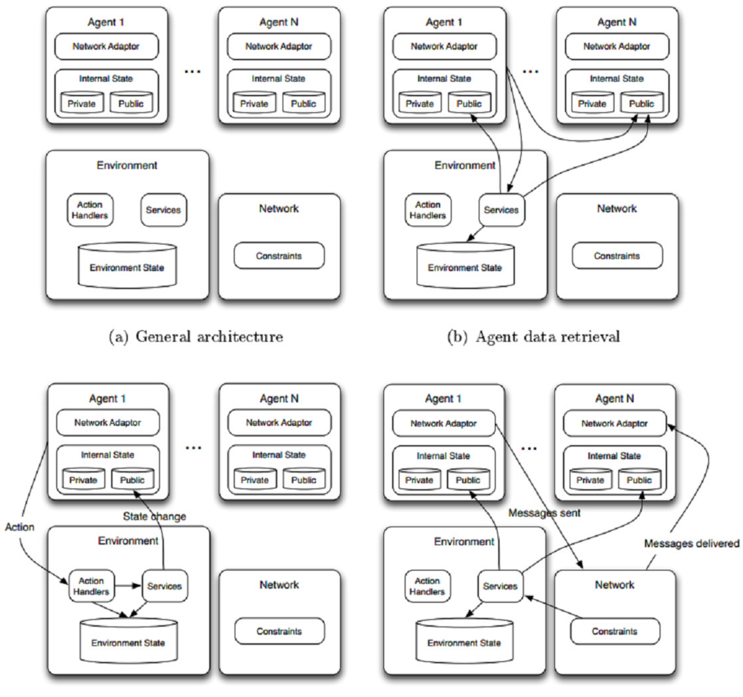
- Autonomous: Agents act independently
- Local view: no Agent can see or manipulate the environment it is in
- Decentralised: There is no Agent which controls the action of all Agents

In reality, individual households which are represented by Agents in the simulator all perform actions according to their individual and unique needs, and not controlled by a third party. This makes Autonomy and Decentralisation a requirement for the Agents in the Simulator. Participants or households connected to the network can't directly control how other participants use or generate electricity for the Common Resource Pool, making it an requirement for the Agent to have a Localised view.

About Presage 2

Presage 2 is a simulation platform for multi-nodal or Agent simulation of societies. The platform was built by Sam Macbeth and is currently maintained by PhD students within Imperial. This platform was chosen for the simulator as it enables the investigation of the impact of agent design (such as household behaviour), network properties (constraints on access) and the physical environment on individual agent behaviour and long-term global network performance.[7] In the context of this Project, each Node/Agent can represent individuals, households, businesses or generators.

Presage 2 was chosen for this project as it is a platform which allows the rapid prototyping of complex Agent societies. Presage 2 Agents are only allowed to act during increments of time steps, which makes the simulation a discrete time driven one. Figures 2.1 and 2.2 illustrates general and simulation archtecture.



(a) General architecture (b) Agent data retrieval

(c) Agent acting (d) Agent messaging

FIGURE 2.1: Presage 2 architecture[1]

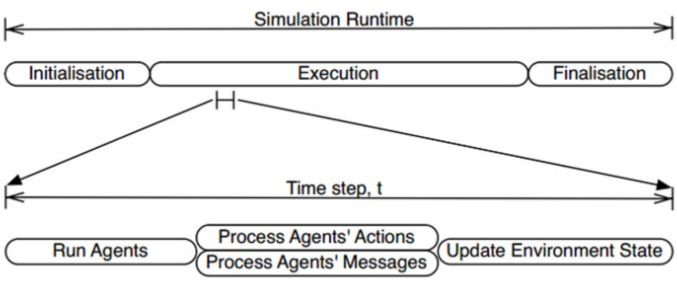


FIGURE 2.2: Presage 2 simulation architecture[1]

Rural Communities in Rwanda

With an estimated 25% rural electrification rate in 2009,[4] rural Africa is one obvious candidate for simulation scenarios. Vast amounts of rural communities remain un-electrified. For a realistic simulation scenario, knowledge of existing infrastructure in place will need to be obtained. With many areas within many countries in Africa, Rwanda in particular has been identified as a good potential simulation scenario to research. Data is difficult to source for rural communities in developing countries, however in the case of Rwanda, some data can be easily from the student society e.quinox. e.quinox is a student-led society which aims to find a scalable solution for rural electrification who mainly operate in Rwanda.[8] The subsections below outline some of the ways remote rural communities are able to access electricity in Rwanda.

Electricity Generation

One of the solutions currently being implemented by e.quinox is the "Energy Kisok" model.[9] The "Energy Kiosk" model features an Energy Kiosk - a building where the generation, storage and distribution of electricity takes place. In e.quinox operated kiosks, electricity is generated from renewable sources. Traditionally, this has been with solar panels. However, hydro-electric generation has been demonstrated to be feasible with the recent construction of a "Hydro Kiosk" at Rugaragara Falls in Southern Rwanda.

Storage and Distribution

Within each kiosk, electricity that is generated is stored in storage batteries placed in the kiosks. The storage batteries regulate power output and allows access to electricity in the kiosk even during periods of no electricity generation.

Battery Box

In the absence of any electricity distribution infrastructure, e.quinox has traditionally provided a number of portable batteries for the purpose of electricity distribution. An example of the portable batteries can be seen in Figure 2.3.

Consumers from local community pay to hire the battery boxes under one of two payment schemes: pay-per-recharge and pay-per-month.[10] The biggest difference between the two schemes are that users can recharge as often as they would like with pay-per-month. Both payment schemes involve the recharge of the boxes at the energy kiosk when they are depleted of energy.

A potential use case of this project can be the simulation of charging of battery boxes at an energy kiosk. This could alleviate congestion and improve asset utilisation of the existing distribution systems by reducing the turn-around time of battery boxes for customers.

Micro Grid

With the recent completion of a hydro-electric kiosk. e.quinox for the first time has a kiosk with access to an always-on generator. With a limited number of battery

FIGURE 2.3: First Generation e.quinox Battery Boxes deployed at Rugaragara Falls Kiosk

boxes in circulation and a constant generation available during the off-peak hours, there is excess capacity for electricity generation.

To improve utilisation of the generator in the kiosk, e.quinox has recently started conducting a feasibility study into constructing a transmission line and a distribution network which will serve a village near the kiosk with a view to make the most of the electricity generated.

Preliminary surveys conducted in the nearest village to the kiosk indicates the demand could exceed the amount of excess power generated by the kiosk.

The result of this project can be used in conjunction with e.quinox to conduct the feasibility study of implementing the Micro-Grid. Should a trading platform for energy also be built, the Micro-Grid could serve as a test-bed for this new system.

Standalone Solution

The Standalone Solution is an independent electrification solution which was recently developed by e.quinox for customers who live far from energy kiosks.

The Stand-alone solution consists of a pay-as-you-go solar electricity generation and storage kit, known as the Izuba.Box.[11] With the Izuba.Box, customers no longer have to travel regularly back to the Energy Kiosk for electricity. Solar panels are installed on the customerâĂŹs roof, and is connected to a sealed box which contains a large battery box. The attached large battery box allows a regulated power output and access to electricity during dark hours.

With the customers not returning to Energy Kiosks, the battery boxes are not hired out like the battery boxes are. The high capital costs of the independent solar system is spread over typically a two year rent-to-own payment plan using a mobile payment system.

It is hoped that the Standalone Solution and additional generation from the Energy Kiosk can be complemented the battery boxes in circulation to provide a continuous access to electricity to all households in the village.

Figure 2.4: First Generation Izuba.Box deplyed in Minazi, Northern Rwanda

Rugaragara Falls as a Simulation Scenario

In developing countries such as Rwanda, poor communities with no access to grid electricity are often in isolated locations such as Rugaragara Falls. The local District Sector office estimates Grid Access won't be available before 2020. In these areas, access is often difficult, making fuel for generators often difficult to obtain. Therefore, locals often depend on other available sources of electricity such as solar and wind power. However, these methods of generation provides highly variable amounts of energy which depends on other variables such as weather. Without access to redundancies received from the national electricity grid to ensure continual access to electricty, it can be beneficial for prosumers within these areas to form a micro-grid, which in many cases would be cheaper than connecting to the national grid.

Requirements and Design 3

In this project, a model of a rural electricity network that is disconnected from the grid is expected to be modeled. To allow the network to be scalable, the network is holonic in structure and consist of communities of prosumer "smart households" which can generate and utilise electricity depending on their demand and generation profiles. Therefore the simulator was required to have the following features:

- Multiple Forms of Generation: Renewable and Non-renewable generators which can operate continuously or discontinuously
- Realistic Generator Models: Programmable variable generation power output to simulate wind and solar power
- Multiple demand centres: the simulation will be of one or more communities operating with a number of households/businesses requiring electricity
- Self organising by the system to allocate the available power fairly to all users
- Presage 2: The simulation will be programmed in Java using Presage 2.

As this was a simulation implemented in Presage 2, there were no specific requirements which must be adhered to with regards to speed, portability and performance.

The simulation was developed using Presage 2, with the hope that a network of Decentralised Community Energy Systems can be simulated, and an algorithm for fairly allocating available generation to demand will be implemented. It is assumed that no cheating will take place.

Model Assumptions

For the purpose of this project, all participants in the community micro-grid must be prosumers. This means all participants are expected to contribute and consume electricity. Some important assumptions will be made about how the system operates in order to simplify the implementation of both the model and the micro grid:

- No losses would be incurred by the network
- All load on the network will be purely resistive
- All generation will act as negative load
- Only basic appliances such as phones, lights and fridges will be connected to the vast majority of households
- All prosumer households will have a battery

- Demand requests are made automatically based on their consumption at the time without user intervention, and therefore there cheating will not take place
- A household will have multiple power outlets. Consumption is measured by the amount of power required to power all of these power outlets with appliances connected at full power
- If allocated power is below the required amount to power all of the outlets, some of the outlets will be automatically turned off by a automatic load shedding mechanism. The order which the outlets are turned off can be set by the user so the user can make sure the most important appliance is connected to the outlet that will be the last to switch off

Model Design

To allow the Community Energy System to work as a holonic system, the micro-grid has been designed akin to the simplified model in Figure 3.1. The Agents in this case are reprsented by the Circles labeled A-H, with various demand/generation equipment connected to the Agents. The Agents are connected to a Virtual Agent or a Parent Agent represented by the single black dot that all Agents on the periphery are connected to in Figure 3.1. As the simulator is a Multi-Agent System, A Virtual Agent is employed to easily represent Group Demand and Group Generation of a small community.

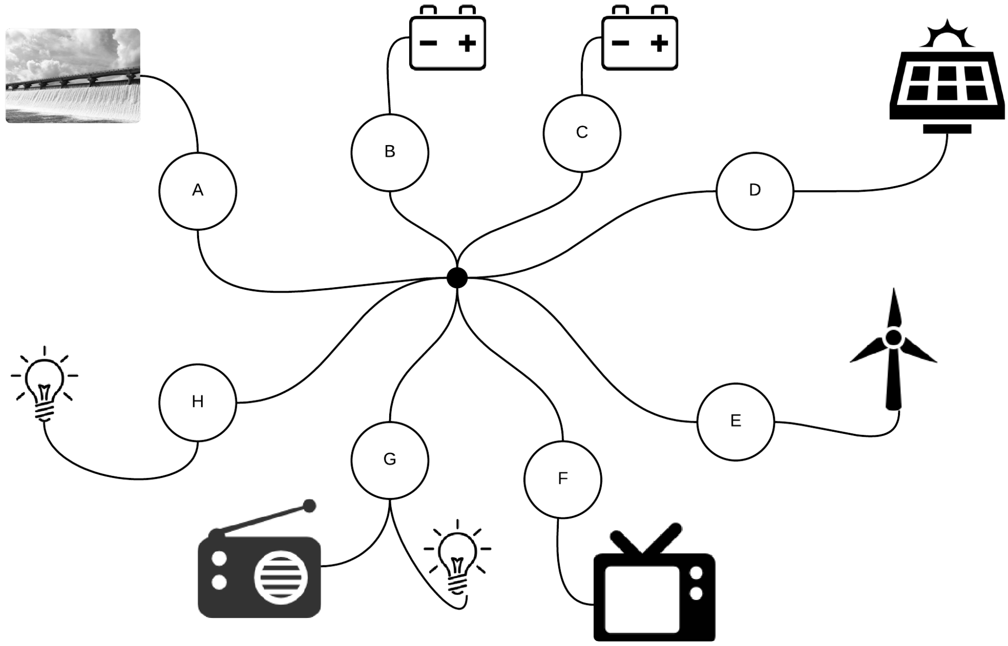


Figure 3.1: A simplified model diagram

Agents that group together are connected to a central virtual agent to allow the agents to form a community. These communities can further connected to another virtual agent to form even larger communities demonstrated in Figure 3.2.

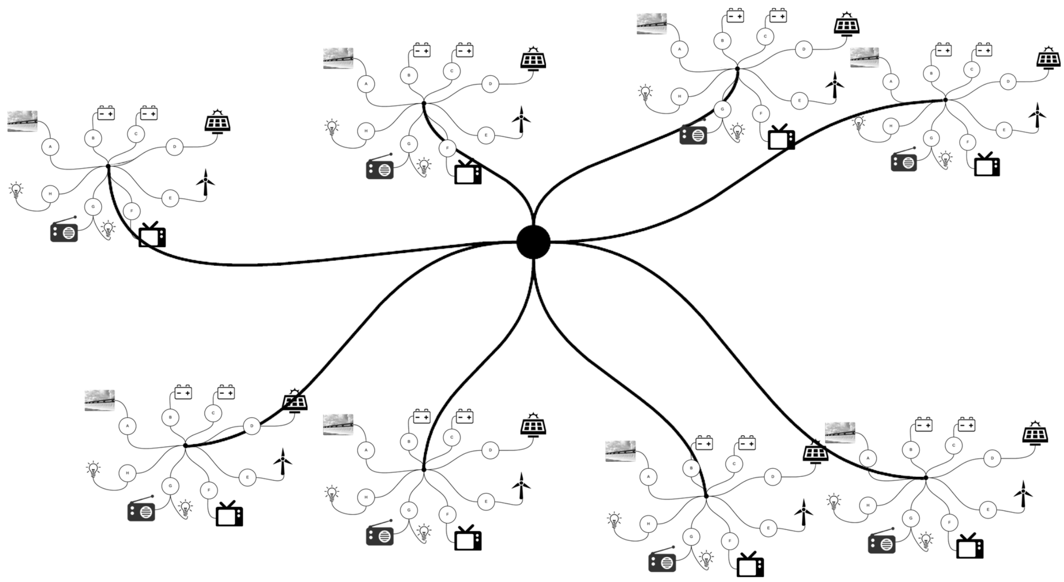


Figure 3.2: A simplified network model diagram

Types of Agents

A Multi-Agent System's main components are Agents, which are the actors which can act on the environment. Outlined below are the Agents that will be implemented as part of the simulator.

Virtual Agents

Virtual Agents represents all connected sub-communities or Agents in a community of Virtual Agents. These Agents will be responsible for enforcing quotas on connected sub-communities or Agents and collecting Generation for the Common Pool.

Prosumer Agents

Agents represent the most "elementary" system such as generators, households, businesses and other demand centres.

Agent Properties

Agent Properties represent the information that is to be relayed to the Community or Institution that the Agent is part of.

Demand - All Agents will also have the Demand property which represents aggregated electricity consumption at a point of connection. Assumed demand curves will be produced from survey data of potential customers in the area for the initial testing. Should the survey data not be available for the area, a reasonable approximation will be made based a predicted usage habits of the wider local population.

It is anticipated that the final simulation will have a desired demand profile that each agent will aim to have.

For Virtual Agents, this property represents the aggregated Demand of all connected sub-communities or Agents and will not have any associated Demand profiles.

Generation - All Agents will have a Generator property which will allow all agents to generate power. For Virtual Agents, this property represents the aggregated Generation of all connected sub-communities or Agents. Four types of generator properties will be implemented in this simulation model for Prosumer Agents:

- Hydro-electric - a constant source of energy based on a mixture of historical data and projections.
- Solar - a source of energy following the typical output profile of a solar panel connected to households.
- Wind - a source of energy which will be highly variable in output.
- Diesel - a constant source of energy.

With the power output of renewable sources of energy such as wind and solar being non-predictable in nature, one of two approach will need to be undertaken to model these sources:

- A probabilistic generating factor is applied to the wind turbines. A constant amount of power each is assumed to be produced for a random amount of time at a random hour of the day that is to be determined. This can also happen for a random amount of times.
- An average generation power output curve is used for solar panels

A variation of both approaches are currently in use by distribution networks in the UK for assessing network congestion.[12]

Storage - Storage devices will be batteries of various types that can be connected to the network. For the purpose of this project, it will be assumed that all Prosumer Agents will have one of these to allow allocation of electricity on a hourly basis.

The Storage property should be designed have the capability to prioritise the allocation of its stored energy for certain Agents. For example, the energy output of Storage-only agents could be made to always prioritise the households they are attached to. If the battery box is communal or belongs to a centralised entity such as an e.quinox Energy Kiosk, then no priority will be attached.

Simulation with Presage 2

For the initial implementation and testing, the model will only contain two levels of Aggregation (see 3.3 below):

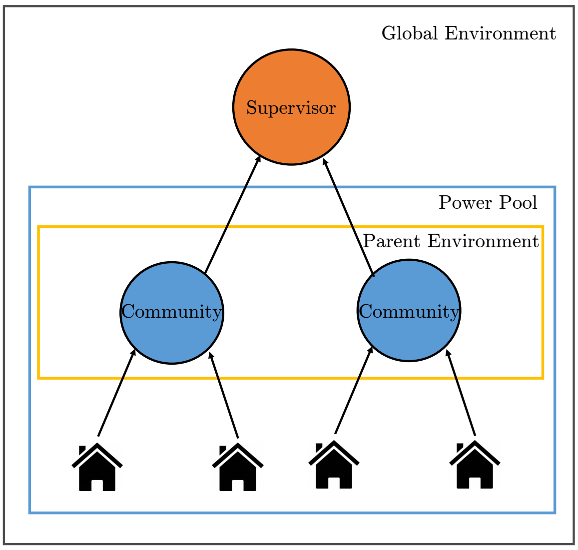


FIGURE 3.3: A simplified overview of the simulation structure

During a round, Agents (or the houses in 3.3)are expected to publish their Demand/Generation request to the Virtual Agent that they are connected to. The Community that these parents are part of are represented by Virtual Agents. The Virtual Agent aggregates the connected Demand/Generation requests and publishes this information to the Supervisor. The Supervisor aggregates the total Demand/-Generation and appropriates the electricity fairly, and curtails the generation if there is an excess.

Fair Appropriation of the Common Pool Resource

With a lot of generation provided by renewable sources, there will be occurences when the aggregated Demand requests will be exceeded by the aggregated Generation requests. In circumstances such as these, the electricity will need to be fairly allocated to all users. Rescher had observed that a fair allocation can be found by distributing as part of 7 canons known as Rescher's Canon of Distributive Justice:

1. Treatment as equals
2. Treatment according to their needs
3. Treatment according to their actual productive contribution
4. Treatment according to their efforts and sacrifices
5. Treatment according to a valuation of their socially-useful services
6. Treatment according to their ability, merit or achievements

Implementation 4

In this section, how the design is implemented will be described in detail

Agents

Agents in Presage 2 are created by extending the AbstractParticipant class. As Virtual Agents and Prosumer Agents behave in a similar fashion, the Prosumer Agent is designed to extend the Virtual Agent with additional properties such as ParentID and ability to add Demand/Generation profiles.

Environment Services

All Agents act within Environments, which would contain shared state between Agents. In the context of this simulation shared state would be information such as the amount available in the Common Resource Pool.

Action

To act on the Environment or acess a shared state in the Environment, Agents are expected to perform an Action. In the context of this simulation, Action would be Demand/Generation requests. As Generation can be modelled as a negative Demand, a single Action can be defined to allow the contribution and appropriation of electricity.

Action Handlers

To enable the Environment to be able to process the Action requests, Action Handlers need to be created to tell the simulation how to deal with Actions from Agents.

Simulation

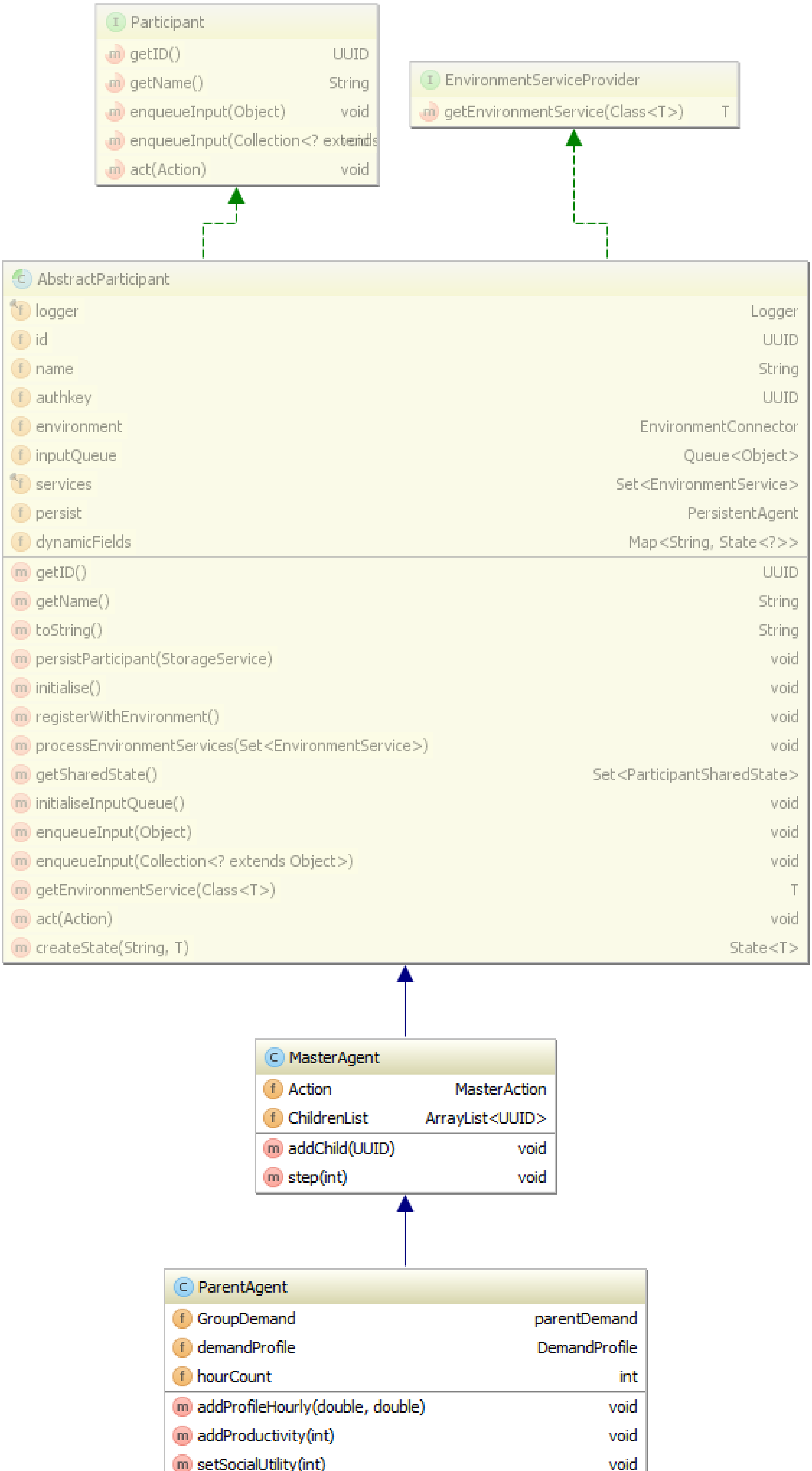
Issues

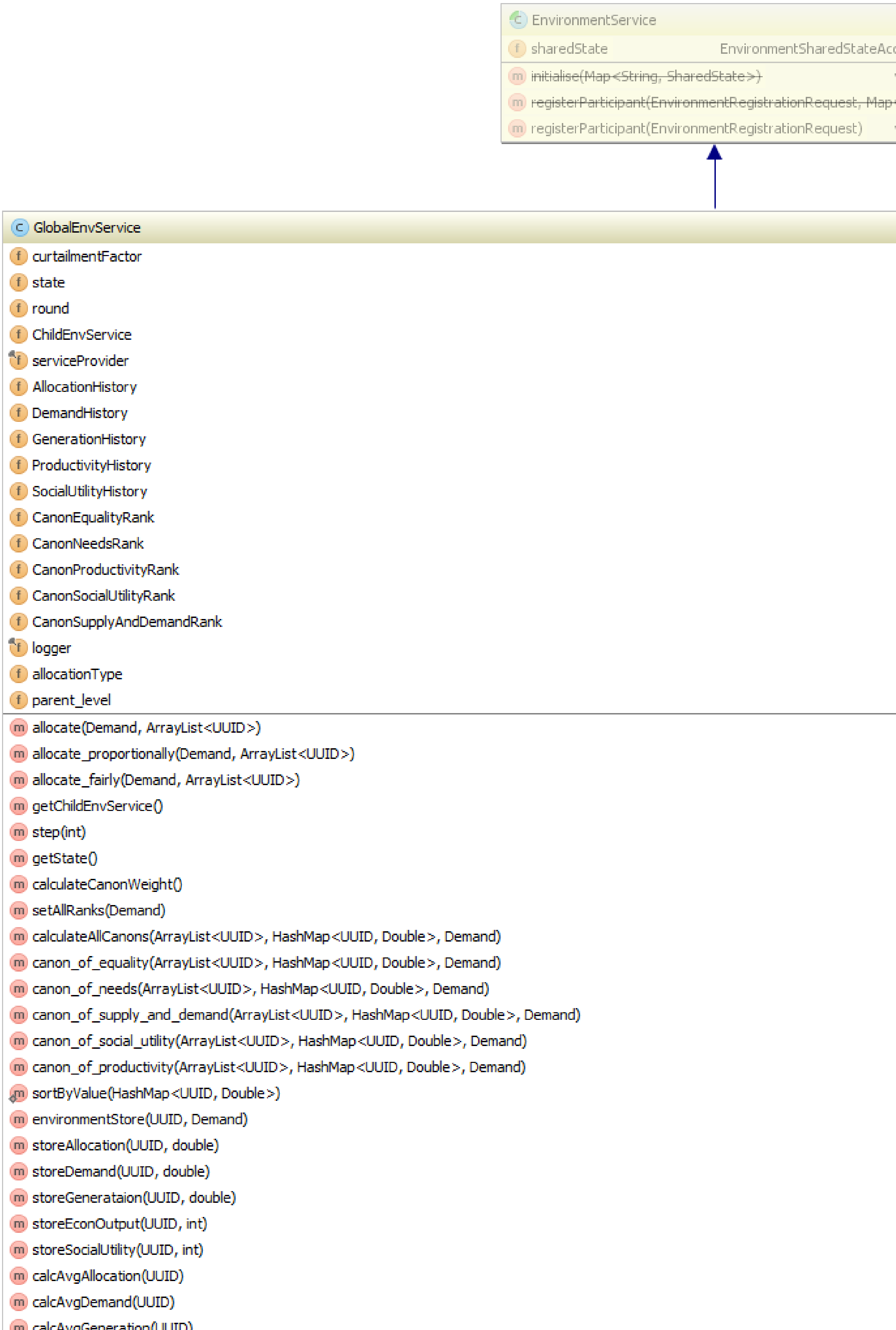
Out of order parallel execution meant that Agents need to submit their individual Demands to the SharedState, and have that summed at the end of each timestep. It is not possible to sum the Demands on the fly.

Being new to both Java and Presage presented problems of its own. It was difficult to understand how simulations could be run and therefore create our own.

One action per time step meant that it takes 4 time steps to simulate one round of request and appropriation of electricity. It would therefore take 24*4 time steps to simulate a full day of requests and appropriation.

Difficulty with initialising Agents with arrays meant that Agents had to be created with no Demand or Generation Profiles, and the Demand and Generation Profiles were added one by one via a for-loop and the addProfileHourly() method.


Participant
getID() UUID
getName() String
enqueueInput(Object) void
enqueueInput(Collection<? extends
act(Action) void
EnvironmentServiceProvider
getEnvironmentService(Class<T>) T
AbstractParticipant
logger Logger
id UUID
name String
authkey UUID
environment EnvironmentConnector
inputQueue Queue<Object>
services Set<EnvironmentService>
persist PersistentAgent
dynamicFields Map<String, State<?>>
getID() UUID
getName() String
toString() String
persistParticipant(StorageService) void
initialise() void
registerWithEnvironment() void
processEnvironmentServices(Set<EnvironmentService>) void
getSharedState() Set<ParticipantSharedState>
initialiseInputQueue() void
enqueueInput(Object) void
enqueueInput(Collection<? extends Object>) void
getEnvironmentService(Class<T>) T
act(Action) void
createState(String, T) State<T>
MasterAgent
Action MasterAction
ChildrenList ArrayList<UUID>
addChild(UUID) void
step(int) void
ParentAgent
GroupDemand parentDemand
demandProfile DemandProfile
hourCount int
addProfileHourly(double, double) void
addProductivity(int) void
setSocialUtility(int) void


EnvironmentService
sharedState EnvironmentSharedStateAc
~~initialise(Map<String, SharedState>)~~
~~registerParticipant(EnvironmentRegistrationRequest, Map~~
registerParticipant(EnvironmentRegistrationRequest)
GlobalEnvService
curtailmentFactor
state
round
ChildEnvService
serviceProvider
AllocationHistory
DemandHistory
GenerationHistory
ProductivityHistory
SocialUtilityHistory
CanonEqualityRank
CanonNeedsRank
CanonProductivityRank
CanonSocialUtilityRank
CanonSupplyAndDemandRank
logger
allocationType
parent_level
allocate(Demand, ArrayList<UUID>)
allocate_proportionally(Demand, ArrayList<UUID>)
allocate_fairly(Demand, ArrayList<UUID>)
getChildEnvService()
step(int)
getState()
calculateCanonWeight()
setAllRanks(Demand)
calculateAllCanons(ArrayList<UUID>, HashMap<UUID, Double>, Demand)
canon_of_equality(ArrayList<UUID>, HashMap<UUID, Double>, Demand)
canon_of_needs(ArrayList<UUID>, HashMap<UUID, Double>, Demand)
canon_of_supply_and_demand(ArrayList<UUID>, HashMap<UUID, Double>, Demand)
canon_of_social_utility(ArrayList<UUID>, HashMap<UUID, Double>, Demand)
canon_of_productivity(ArrayList<UUID>, HashMap<UUID, Double>, Demand)
sortByValue(HashMap<UUID, Double>)
environmentStore(UUID, Demand)
storeAllocation(UUID, double)
storeDemand(UUID, double)
storeGenerataion(UUID, double)
storeEconOutput(UUID, int)
storeSocialUtility(UUID, int)
calcAvgAllocation(UUID)
calcAvgDemand(UUID)
calcAvgGeneration(UUID)

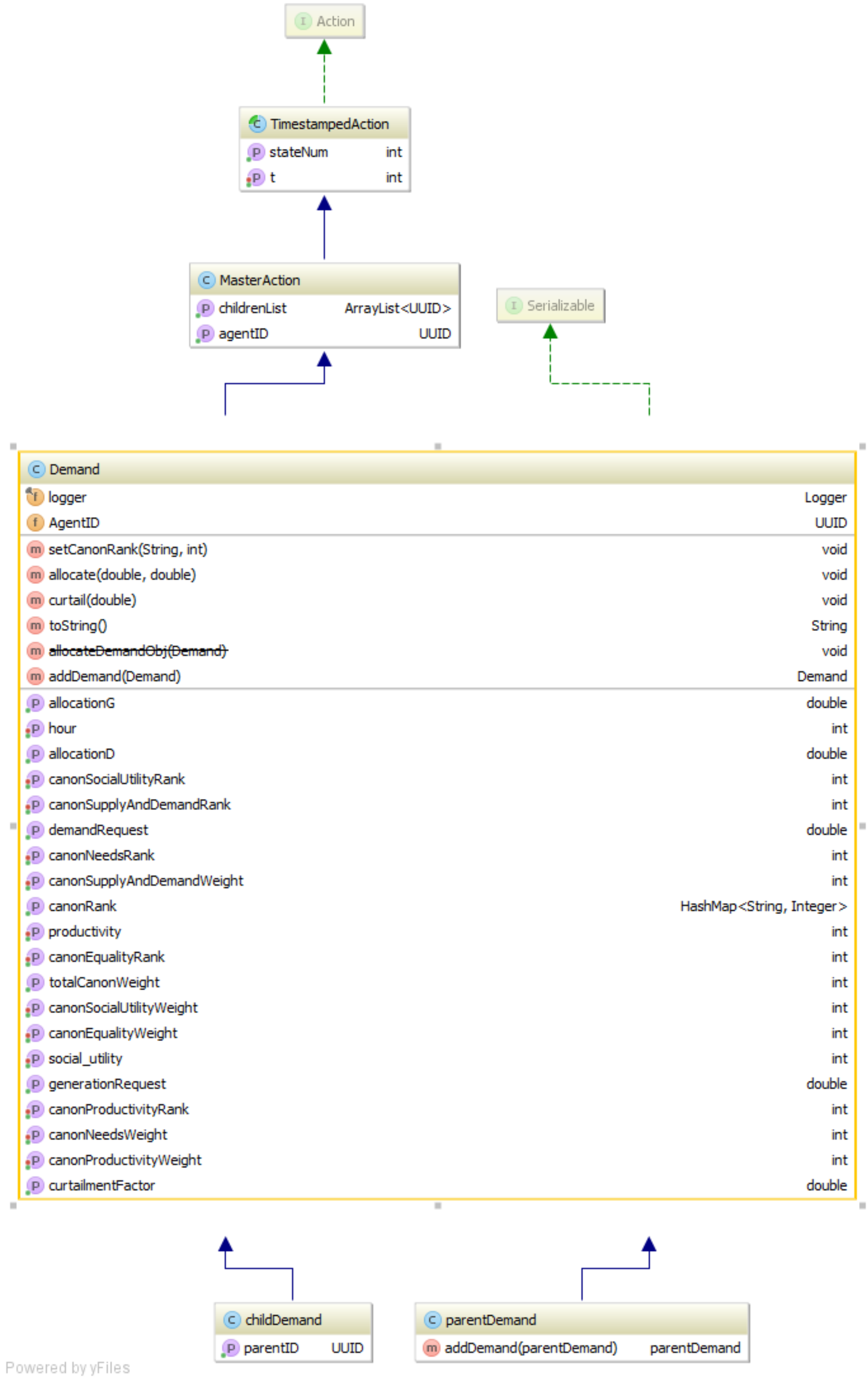


FIGURE 4.3: Actions UML Diagram

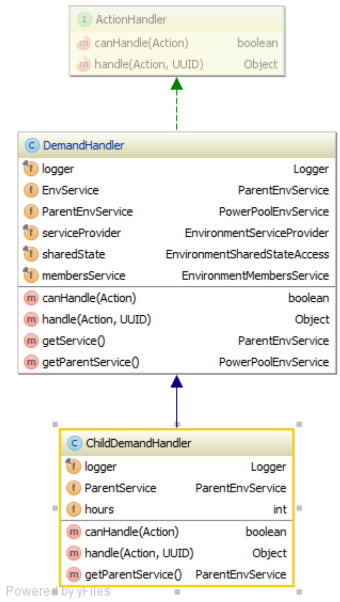


Figure 4.4: Action Handler UML Diagram

Testing 5

The final product of this project should be a realistic simulation of a Decentralised Community Energy System. To produce the simulation, each of the following features will be tested to ensure they work individually and together:

- A network of Agents able to trade electricity with each other.
- Agents are able to utilise energy. The amount of energy utilised can be predetermined manually by an operator of the simulation or automatically with an algorithm.
- Agents are able to generate an amount of energy corresponding to a preallocated fixed output, or an amount based on their assigned Generation Profiles.
- Each Agent is able to utilise and generate electricity at the same time.

5.1 Contribution to Pool

To test the contribution to the Common Pool,

5.2 Correct Appropriation

Results 6

6.1 One Agent (No Participation)

6.2 Multi-Agent Proportional Allocation

6.3 Multi-Agent Fair Allocation

Evaluation 7

Conclusions 8

Since October, an attempt has been made on understanding the properties of Common Pool Resource, and how electricity can be a Common Pool Resource in the context of a Decentralised Community Energy System. An attempt has been made on building a simulator of a Decentralised Community Energy System in developing countries.

The simulator demonstrated that the

The simulation of the Decentralised Community Energy System will be used to explore possible utilisation patterns within rural communities, and also explore controls for regulating the use of electricity. If the study proves to be successful, an attempt at designing and implementing a trading platform for Decentralised Community Energy Systems will be made.

Further Work 9

So far, the works carried out will be only be applicable for one community in rural Rwanda. It is hoped that work will be carried out to make this applicable to other communities by including more generation types such as biogas, and more types of appliances owned by each house.

In the immediate future, it is hoped that this tool could be used to aid the feasibility study of the Micro-Grid to be implemented in Rugaragara Falls. Should there be time, an energy trading platform will be designed and built based on the model created in this project to provide adequate electricity access to all members of the community. However, the energy trading platform would require a different design and implementation scheme which is not included in this report.

The sections below outlines the various properties each Agent must be able to take and how they could be implemented for the simulation scenario of rural communities in Rwanda. All of the properties must be allowed to exist on the same Agent during simulation.

In addition, the e.quinox Micro Grid is currently undergoing feasibility studies. If time allows, a system could be designed and built for the Micro Grid to allow the trading of electricity between households to guarantee electricity supply for when it is needed. This system however will have a completely different set of requirements, which will be drawn up after the completion of this project.

Consider Diesel Generators' costs Consider satisfaction of individual agents for them to partake in this

In the simulation, carry forward unused generation because we have storage.

User Guide 10

The github source code repository for this project can be found at: https://github.com/yuchen-w/DCES-Simulator

The code was developed in IntelliJ Idea 14.1.3 IDE, however will work fine on Eclipse. Detailed instructions can be found on the readme of the repository.

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