

SCANERGY: a Scalable and Modular System for Energy Trading Between Prosumers

(Demonstration)

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ABSTRACT

We present an interactive demo that illustrates the performance of our multi-agent-based system for trading 'green' energy. The system implements the NRG-X-Change concept and uses real-life data for energy consumption. NRG-X-Change encourages prosumers to locally trade their excess of energy while payments are carried out using NRGcoins, which is a novel decentralized digital currency. We illustrate the performance of a real and typical neighbourhood in Belgium with 62 residential houses, 56 of them are consumers while the remaining 6 are prosumers. Participants can interact with the demo by playing with energy consumption and production, and analyzing in real-time the behaviour of the energy market and in turn the price for NRGcoins.

Categories and Subject Descriptors

I.2.11 [Computing Methodologies]: Multi-Agent Systems

Keywords

multi-agent system; smart grid; renewable energy; energy trading; energy markets

1. INTRODUCTION

If we are to meet the environmental targets and the long-term goals set out by the European Commission (EC) Energy Roadmap 2050 [5], cities must offset their dependence on fossil and nuclear fuels by relying on renewable energies. The domestic penetration of small-scale renewable resources enables consumers to become producers of green energy and empowers dwellings to collectively reduce their carbon footprint by trading locally produced renewable energy.

Rewarding green energy trade incentivises the exchange of locally produced energy and allows consumers, who cannot afford the purchase of renewable generators, to buy green energy at affordable prices. Selling overproduced energy to local consumers reduces transmission losses and offsets the demand for grey energy supplied by the grid. As previously

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described in [4], although there are numerous approaches for trading of locally produced energy, no widely adopted solution exists that aligns the goals of individual agents with the goals of the entire smart grid. In Belgium, for example, the current mechanism does not encourage producers to trade their excess production.

2. NRG-X-CHANGE

In [4] we have proposed the NRG-X-Change concept, which attempts to address the observed flaw using a novel digital currency called NRGcoin [3]. Locally produced renewable energy is continuously fed into the grid, and is withdrawn by consumers. The billing is performed in real-time by the substation, where the feed-in tariff takes into account total supply and demand in the neighbourhood, rather than the individual's supply and demand, as in the Belgian scheme. This tariff incentivises households to balance supply and demand, as well as lower production and consumption peaks. The innovative aspect of NRG-X-Change is that all payments are carried out in NRGcoin, instead of fiat money. This new decentralised digital currency shares characteristics with Bitcoin and has numerous advantages in the smart grid, as outlined in [4]. Independently from injection and withdrawal of energy, NRGcoins are traded on an open currency exchange market for their monetary equivalent.

We use the adaptive attitude (AA) bidding strategy [2], which relies on short-term and long-term attitudes for adapting to market changes. Whereas a short-term attitude encourages the agent to be eager for more profit (i.e. selling/buying at high/low prices), a long-term attitude encourages the agent to be eager for more transactions (i.e. submitting low/high asks/bids). In this way, based on market events (transactions, high bids/asks), AA continuously updates an agent's eagerness to sell or buy NRGcoins. The NRG-X-Change concept has been thoroughly tested on a smart grid multi-agent simulator using Repast Symphony. To further test this innovative concept, we now deploy NRG-X-Change on hardware and use real data of energy consumption in a typical neighbourhood.

3. SYSTEM COMPONENTS

The aim of our demonstration is threefold: (i) to raise awareness about the challenges and impact of possible smart grid scenarios; (ii) to highlight the impact of NRG-X-Change

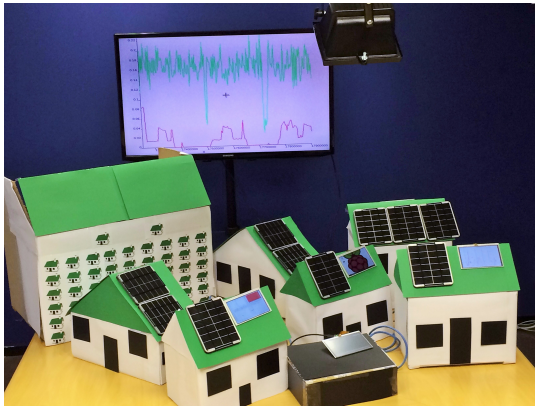


Figure 1: Scanergy Demo setup

on green energy trade; and (iii) to demonstrate the weather influence on monetary incentives and market behaviour.

3.1 User Interaction

Our demo offers three types of interaction. 1) *Change consumption*: Users can change the 'virtual' outdoor temperature, which influences the consumption of all houses. For example, decreasing the outdoor temperature will drive agents to increase their consumption proportionally, relative to their real-world consumption. This simulation of weather conditions allows users to observe the effect of chance on the overall energy balance and on the incentives of agents for exchanging renewable energy. 2) *Reduce production*: Users can hold in the air cardboard clouds that cast shadows over the solar panels of prosumers. 3) *Increase production*: Users can install extra panels to observe the influence of big producers on the real-time energy price and on the energy market. Similarly, equipping a consumer with solar panels increases the percentage of prosumers and therefore changes the energy balance in the neighbourhood.

3.2 Physical Setting

Within the demo we use real-life data, provided by Eandis — a Belgian Distribute System Operator (DSO). All houses in a given neighbourhood are connected via the low-voltage grid to one substation of the DSO. The dataset is comprised of aggregated 15-minute intervals of electricity consumption and production of 2928 homes from 44 substations in Belgium. In this demo we use a typical substation, which contains 6 prosumers and 56 consumers (cf. Figure 1). To find a typical substation, we applied a two level clustering that considers global features such as total trimester consumption, and local features such as daily consumption [1]. The measurements that we used in this demonstration are collected between 1st of March 2014 and 31st of May 2014.

The substation and the six prosumers are represented by software agents running on individual Raspberry Pi boards. Prosumers produce energy in real-time using mini solar panels. A dimmable spotlight projector is automated to simulate the day/night cycle using a z-Wave controller. All 56 consumer agents are running in individual threads on two Raspberry Pi boards. Energy consumption of both prosumers and consumers is simulated using the real data. Boards are connected to the Internet, which allows agents to submit orders for buying and selling NRGcoins to an online market hosted and running in Azure Cloud. Orders are matched in real-time using continuous double auction,

as employed by the New York Stock Exchange. Thus, our demo represents a multi-agent system that autonomously exchanges renewable energy using the NRG-X-Change incentive mechanism. Since the currency market is hosted in the Cloud, it allows agents to place bids from anywhere in the world. Thus, multiple neighbourhoods running in different parts of the world can seamlessly interact in the same scenario and demonstrate the scalability of our concept. All software agents are developed in Java, while the exchange market is developed in C# using Azure Service Bus for synchronizing actions. All components communicate using the RESTful Microservice architecture.

Prosumers have LCD screens showing in real-time: (i) individual energy production and consumption in kWh; (ii) NRGcoin balance of prosumer; (iii) NRGcoin transactions and payments; and (iv) market orders for buying and selling the currency. Likewise, substation's screens show aggregated information about: (a) total energy production and consumption of all houses; (b) NRGcoin balance of the substation; (c) all unmatched buy and sell orders in the currency market; (d) the evolution of the NRGcoin price.

While in reality measurements are taken every 15 minutes, we speed up our demonstration by a factor of 300 to arrive at 3-second time slots. Thus, charts are updated every 3 seconds, allowing users to observe in less than 5 minutes the behaviour of a real neighbourhood in a whole day. Users are also able to pause the execution of the entire demonstration (including the day/night cycle) in order to analyse the plots. This functionality is available via the user interface in the substation's LCD display.

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