Collaborating Smart Solar-Powered Micro- Grids
http://www.cossmic.eu

Agent based negotiation of decentralized energy production

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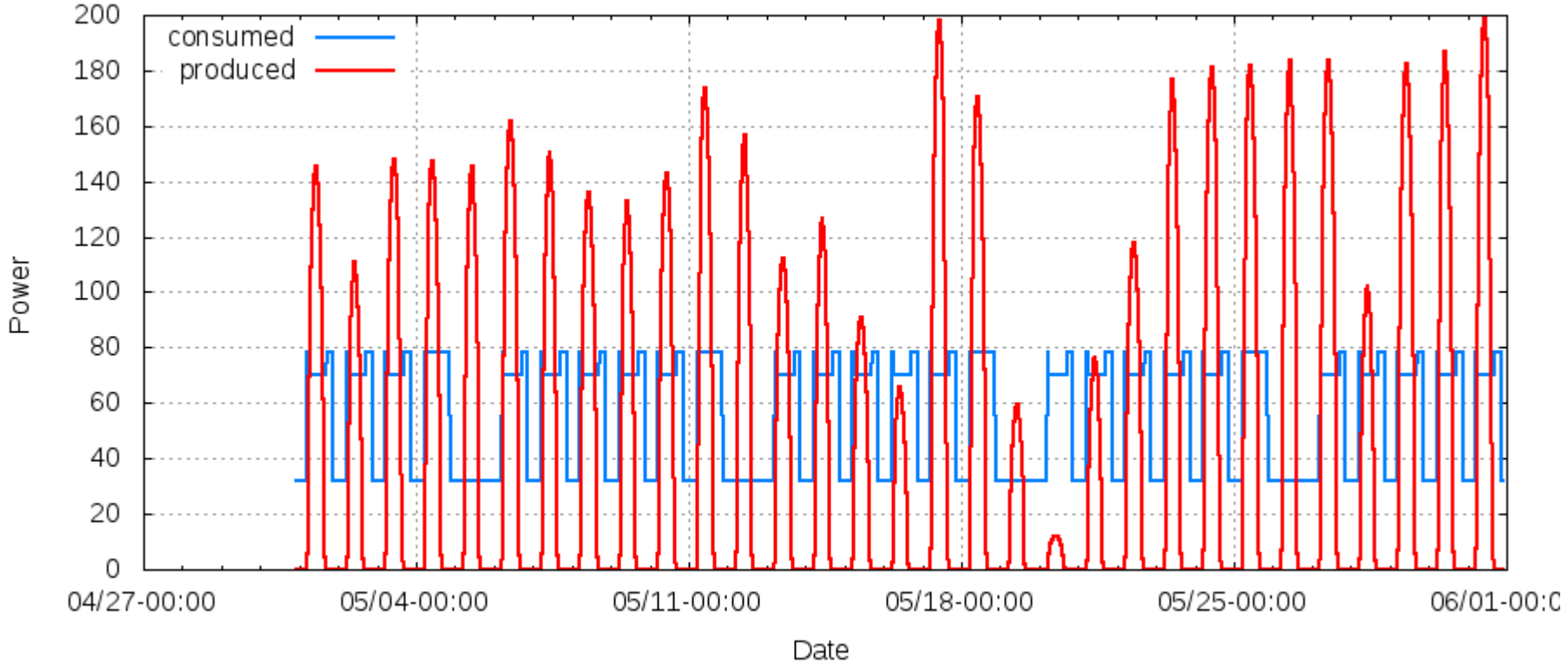
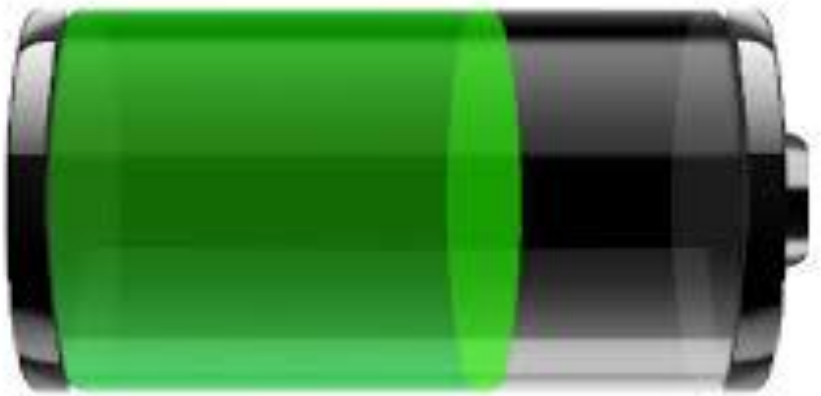
Motivation 1/2

Mismatching between production from:

- Energy produced by Solar Panels
- Energy consumed by households



Motivation 2/2



Indeed, research has shown that while in theory houses can be self-reliant on solar panels by the amount of electricity they produce, it would require considerable (and expensive) storage capacity to realize this.

Objective

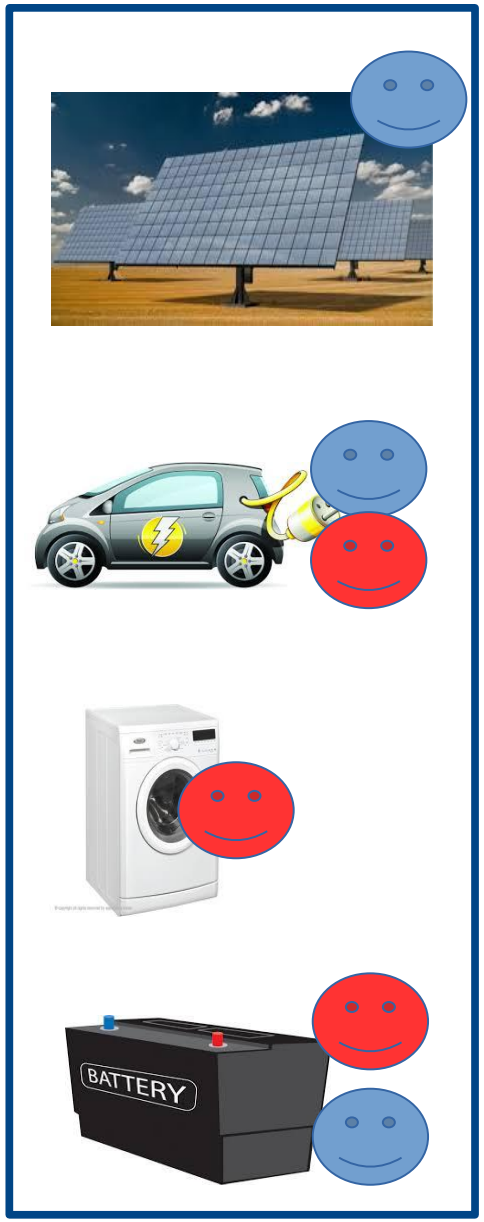
- A combination of IT and telecommunication technologies to enable the saving of energy and resources.
- In this paper we present an agent-based solution that allows:
  - the collection of data about energy consumption in a neighborhood
  - and the negotiation of the whole produced/consumed energy among the involved parties in order to maximize the profits of the community.

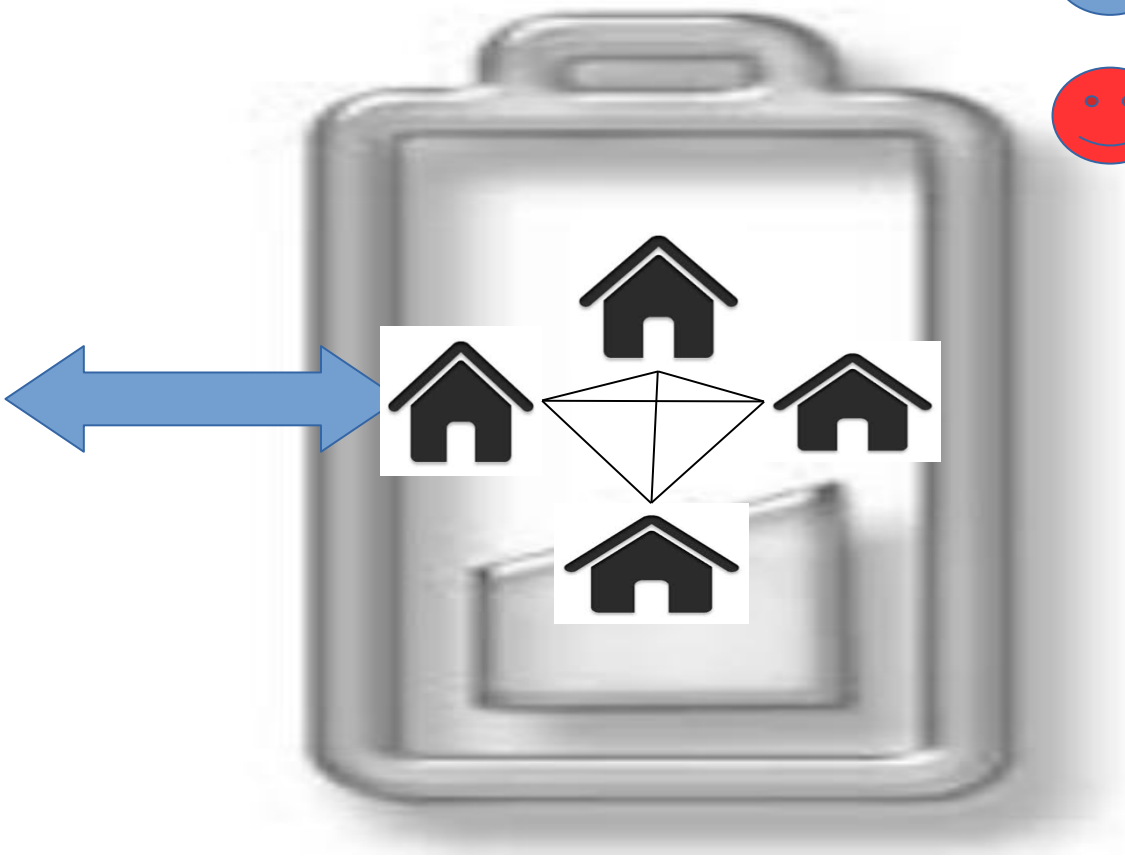
CoSSMic Project

- Project ID: 608806
- Duration: October 1st 2013 - September 30th 2016
- Total cost: 4.267.061 €
- Funded by European commission - Directorate General Connect
- call FP7—Smart Cities –2013
- Funding scheme: Collaborative Project STREP

- CoSSMic is an ICT project that aims at designing an innovative autonomic systems for management and control of power micro-grids on users' behalf.
- Different types of buildings (for instance a mix of houses, companies and schools) could be connected in such a way that this neighborhood would use more, or even most, of its renewable energy within the community.

The CoSSMic solution





Producer

Consumer

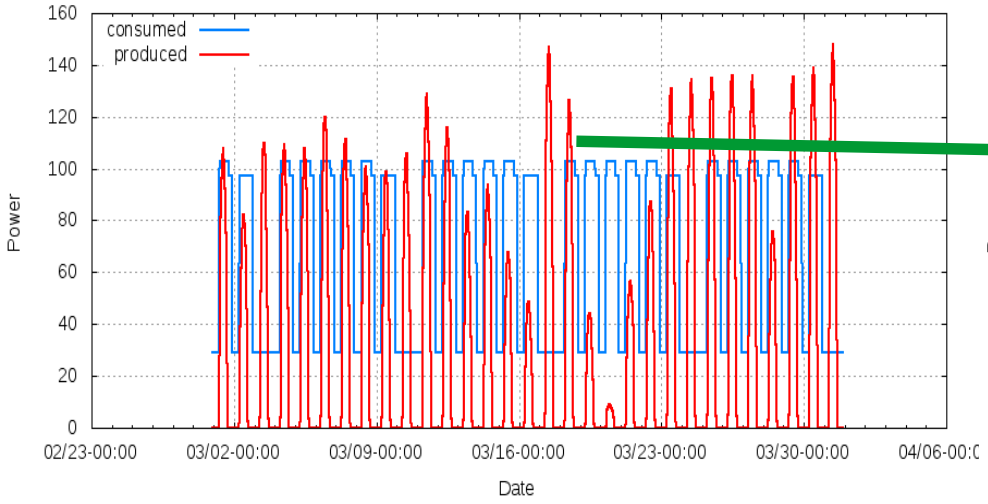
1. Load shift

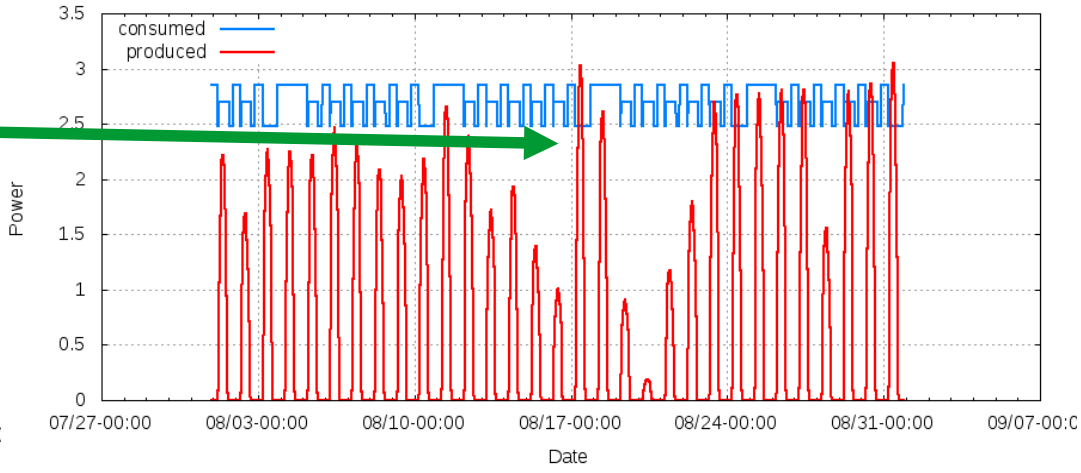
2. Energy exchange

Energy Exchange: Case Study

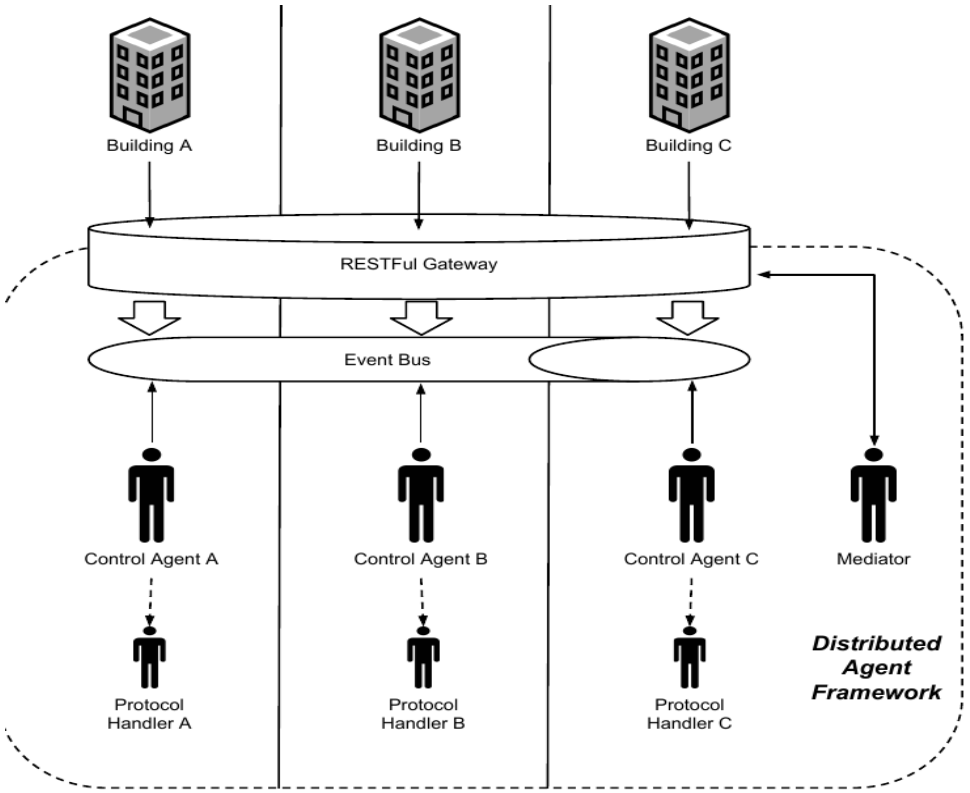
Swimming Pool → Big Plant

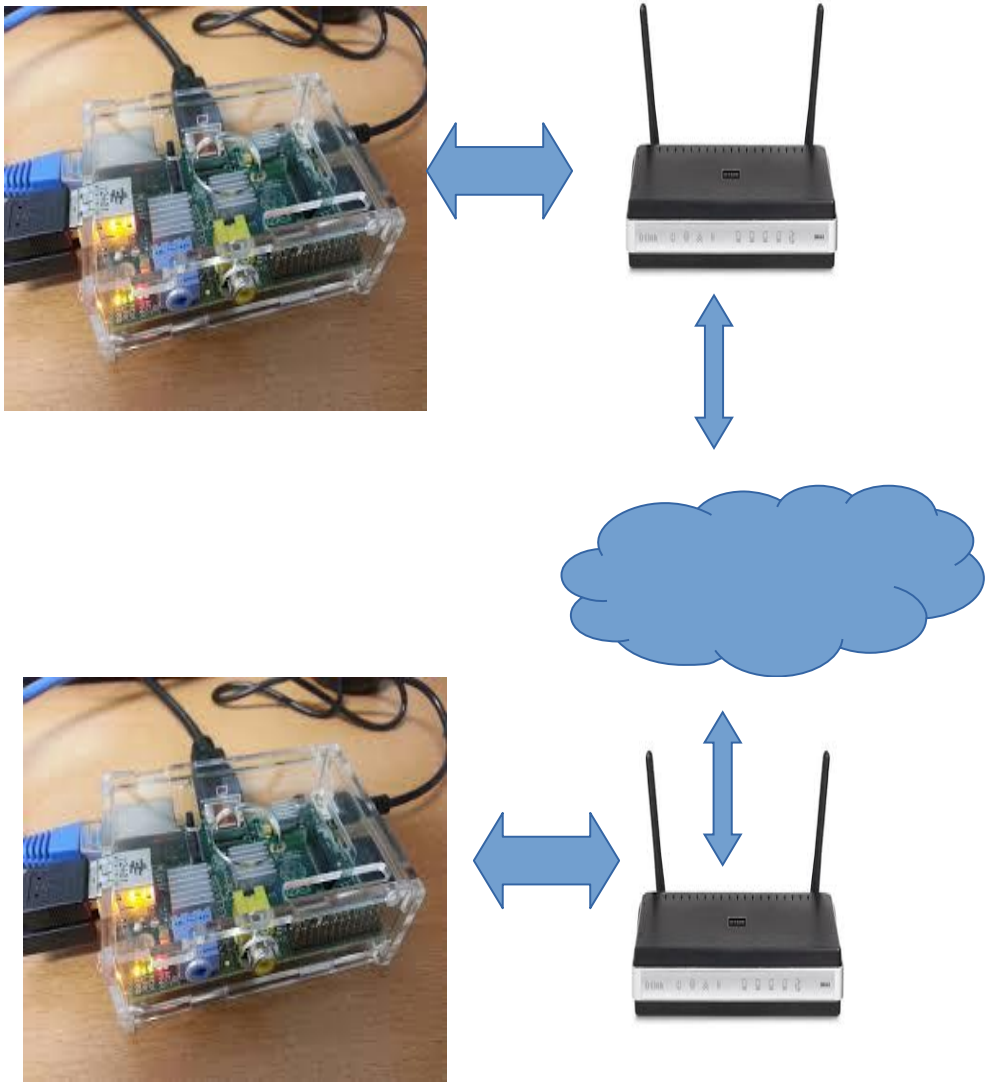
Private households → Small Plants





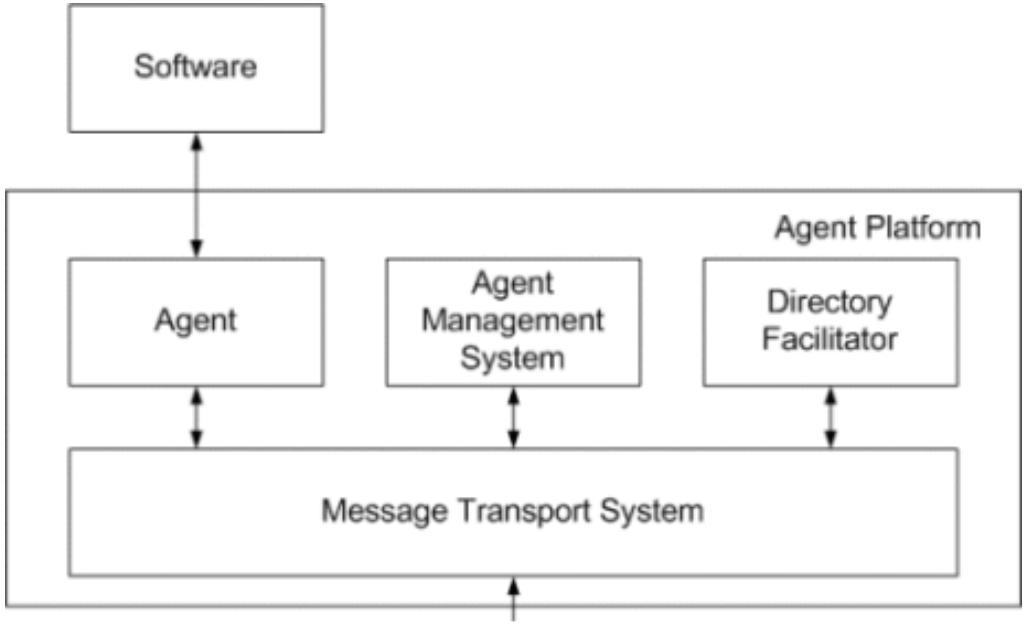
Distributed Architecture



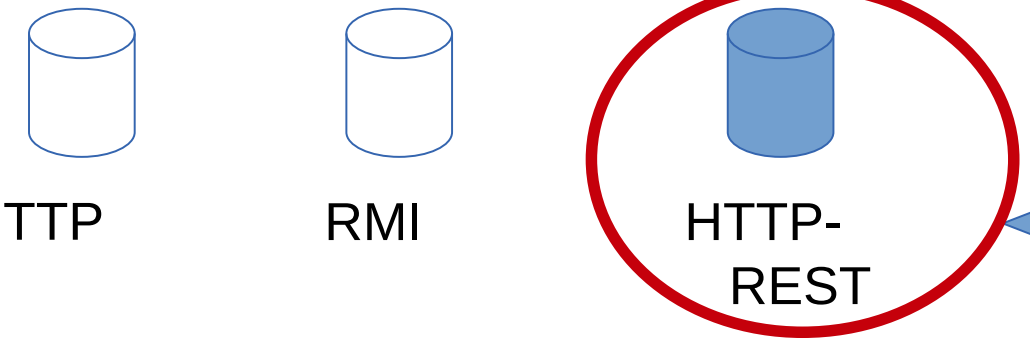


- Agent platform is distributed across buildings
- Agents communicate each others by ACL over XMPP

Jade

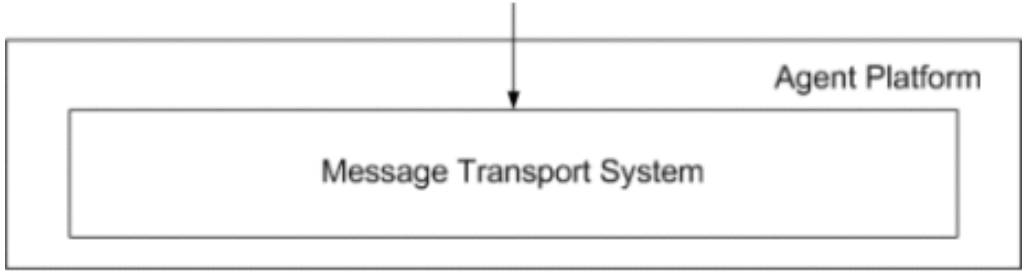


- http://jade.tilab.com/
- Pure Java
- LGPL license



CoSSMic GUI

CoSSMic Mediator



Agent based infrastructure

1. The RESTFull Gateway has been implemented as a new Jade MTP.
2. The Event Bus has been implemented as an agent within the framework.
3. The Mediator Agent is responsible to collect and manage measures inside a building.

HTTP/REST MTP

- Implements a specific service interface
- A device driver can publish some information by a POST HTTP request to http://$ip address:$port/event/ as URL with a JSON string as message body.
- For each incoming HTTP-REST request, the MTP checks the correctness of the request URLS and verifies if all the mandatory headers are filled.
- After that it translates the request and forwards an ACL message to the related agent of the CoSSMic platform.

```
{
"HouseID": "ID of house",
"Date": "Date when event occurs",
"Time": "Time when event occurs",
"EventSource": "Event type",
... ,
"Parameters": {
"Power": "Power consumed/produced",
...
}
}
```

(a) JSON Event

```
{
"AgentId": "ID of agent",
"Power": "Power to sell/buy",
"Price": "Price at which to sell/buy",
"Duration": "Contract duration",
"Interruptible": "If the contract is
                  interruptible or not",
"Protocol": "Protocol to use",
...
}
```

(b) SLA JSON Message

Negotiation Strategy and Protocol

In the first prototype negotiation strategy is very simple:

- the cost of energy is always less than the one fixed by the power supplier (***no fees***).
- In this condition the only parameters that are evaluated during a negotiation are the ***amount of energy*** to buy/sell and ***the duration of the contract.***

Control Agents will purse complementary objectives:

- ***Consumers***: try to get as much energy as it is required from the neighborhood, thus achieving significant savings.
- ***Producers***: try to sell to neighborhood all the overproduction to CossMic consumers, to improve their income.

Negotiation Strategy and Protocol

In our prototype the following conditions have been considered:

1. if a consumer/producer cannot acquire/sell through a single negotiation all the energy, it can accept offers from others until full satisfaction of its needs;
2. if a consumer cannot find enough energy within the neighborhood, it will be forced to contact a GenCo;
3. if a producer fails to sell in a single transaction all the produced energy, it waits for new CFPs from other consumers;
4. if a consumer purchased a certain amount of energy but it does not use it all, it will try to resell the remaining energy (thus working as producer).

Proof of Concept

We used a synthetic workload built up from the bills received from the energy owner of:

- three private houses
- a big plant belonging to a swimming pool.

The considered houses have not devices able to produce energy so the exchange happens along one direction.

Billing information

Building	Production [kWh/year]	Consumption [kWh/year]	Consumed energy in h-c [%]	Consumed energy in l-c [%]
House-01	0	2442	30.40	69.60
House-02	0	2681	34.50	65.50
House-03	0	2604	34	66
Swimming Pool	287100	248800	50	50

Table 1 Energy production and consumption summary

Experimental results

Cost/Reward without negotiation

Building	**Total cost [EUR/year]**	**Reward [EUR/year]**
House-01	398.14	0
House-02	438.21	0
House-03	425.49	0
Swimming Pool	23826	17226

Cost/Reward with negotiation

Household	**From CoSSMic [kWh/year]**	**To CoSS-Mic [kWh/year]**	**From GenCo [kWh/year]**	**To GenCo [kWh/year]**	**Total cost [EUR/year]**
House-01	742	0	1700	0	248.66
House-02	925	0	1756	0	258.03
House-03	885	0	1719	0	252.32
Swimming Pool	0	2553	248800	284547	23774.95

Conclusion

- Theoretically, if we suppose that the pools could store the energy and then sell it in the evening, the household savings is estimated at around 46%.
- Even if the pool produces only during the day and cannot store energy, the amount purchased at a lower price allows the buildings to save about 40%, and to use a relevant amount of green energy.
- Of course the number of buildings is too small and it does not allow to get a relevant benefit also for the swimming pool, which still sells most of the energy produced to GenCo.
- Moreover the data we have not allowed us to simulate the real scenario that can be affected by some fast dynamics not reconstructed by the poor input information.
- A realistic business model should be defined.