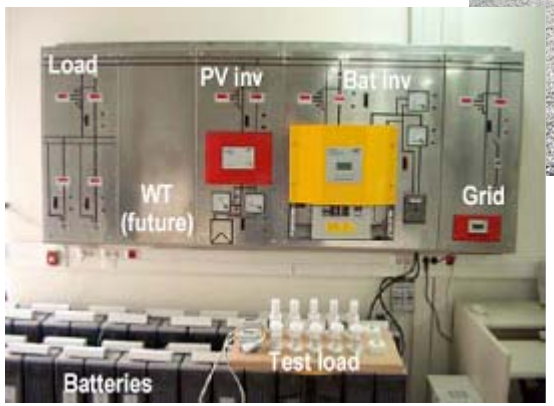
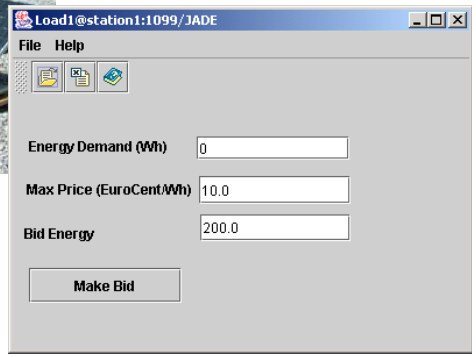
MultiAgent System for MicroGrid Operation





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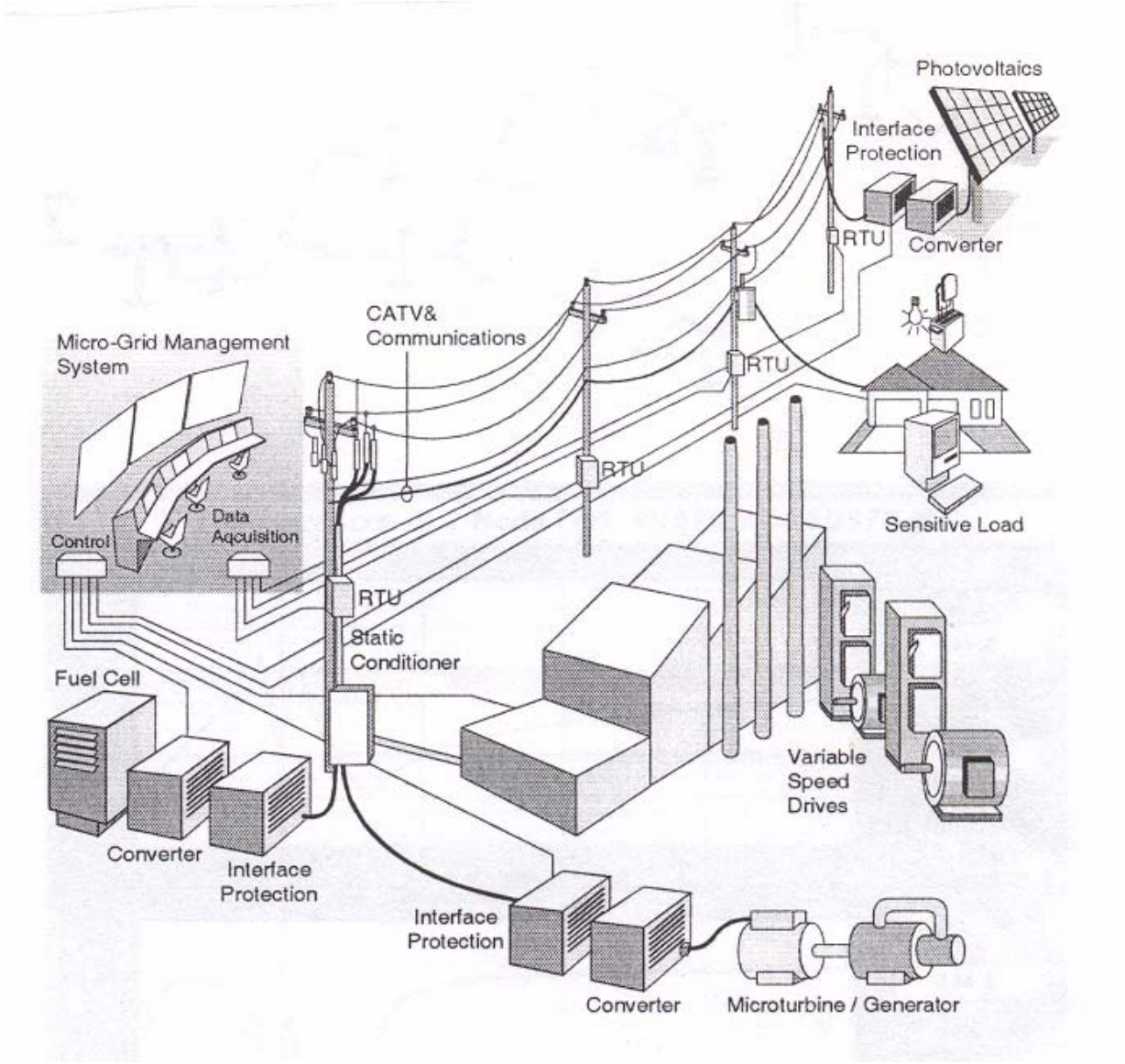
Structure of the Presentation

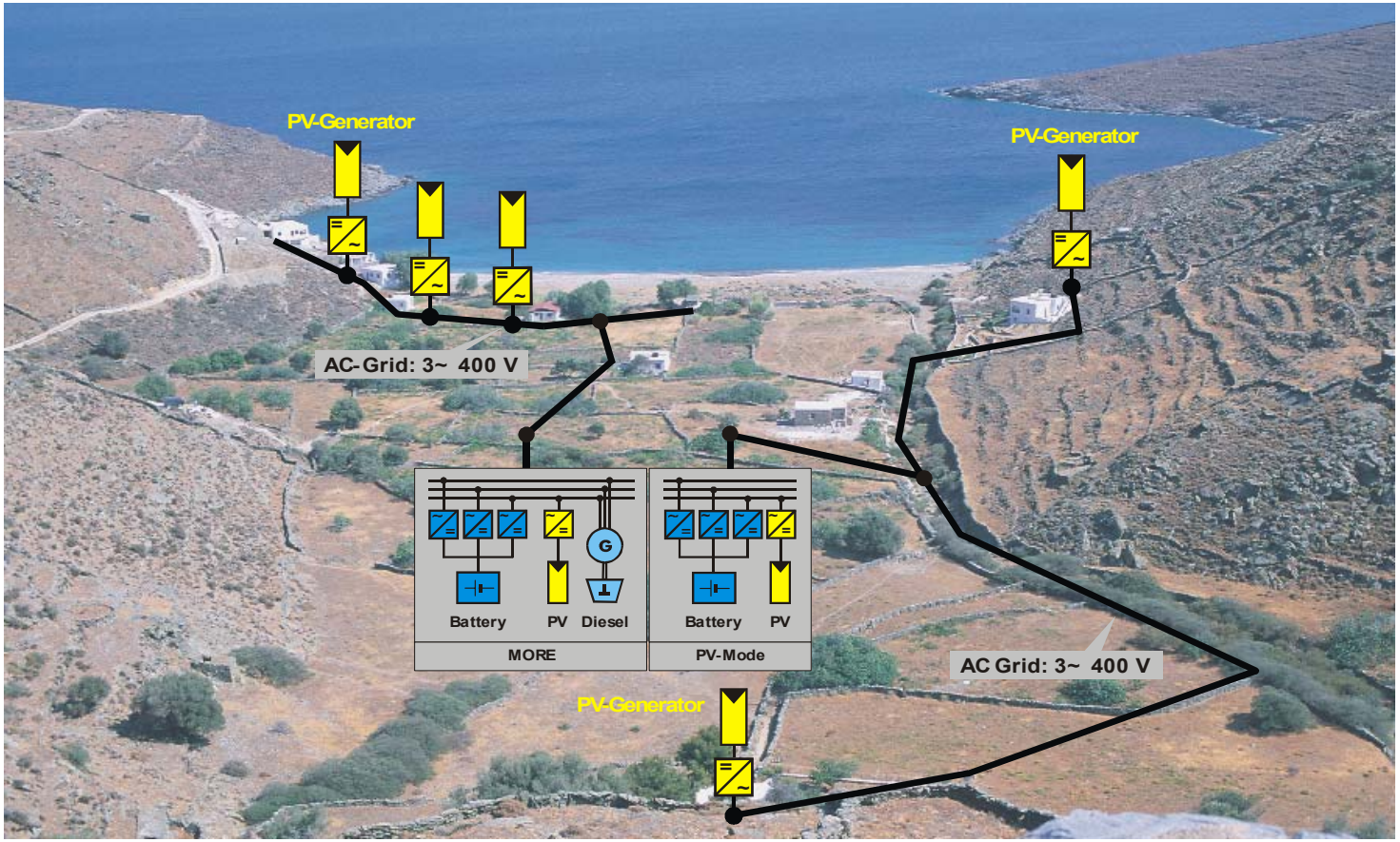
- Description of the MicroGrid.
- Tasks of the MAS
- Description of the implementation.

Description of the MicroGrid

- The interconnection of small, modular generation sources to low voltage distribution systems that form a new type of power system, the MicroGrid.
- MicroGrids can be connected to the main power network or be operated autonomously, if they are isolated from the power grid.

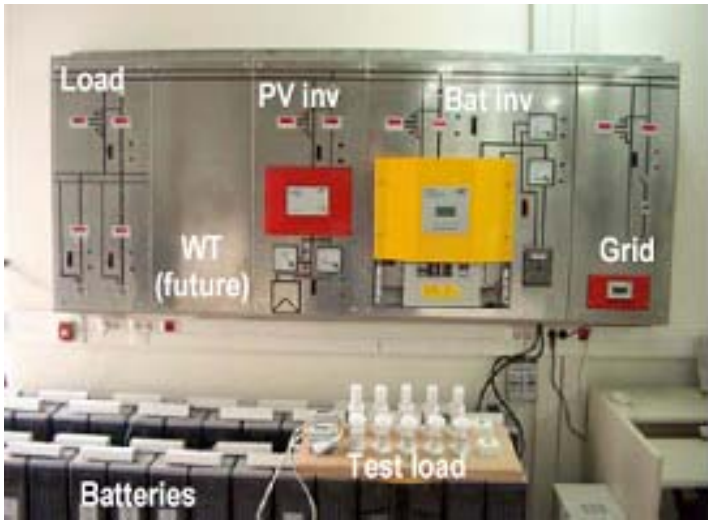

Photovoltaics
Interface Protection
RTU
Converter
CATV& Communications
Micro-Grid Management System
RTU
RTU
Sensitive Load
Control
Data Aqcuisition
RTU
Static Conditioner
Fuel Cell
Variable Speed Drives
Converter
Interface Protection
Interface Protection
Converter
Microturbine / Generator

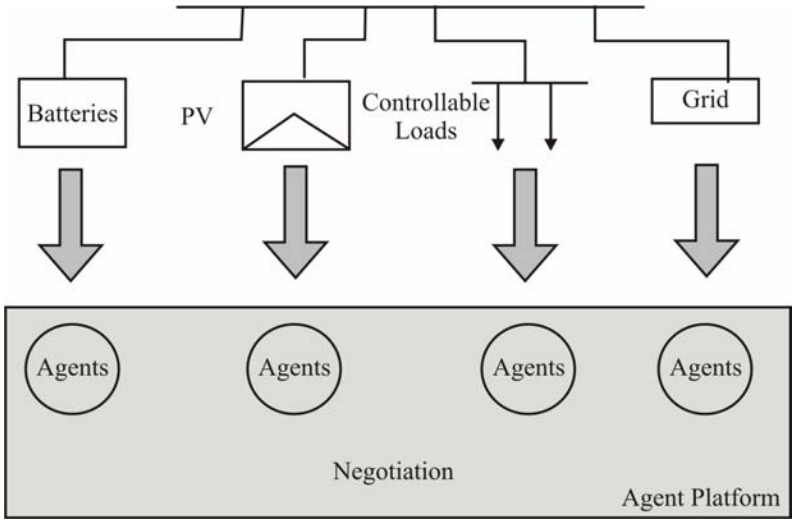
Pilot installation in the island of Kithnos

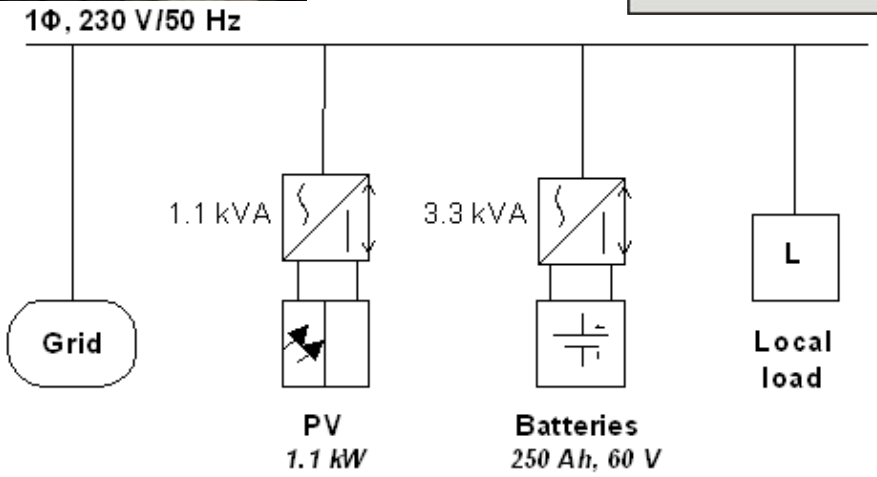


- Supply of 11 buildings (EC funded projects)

The Laboratory Microgrid of NTUA







MAS Technology

The basic element of a Multi Agents System is the Agent:

- The agent acts in his environment.
- The agents can communicate with each other.
- The agents have autonomy.
- The agent have partial or none knowledge of the environment.
- The agent has behavior, targets, resources and skills.

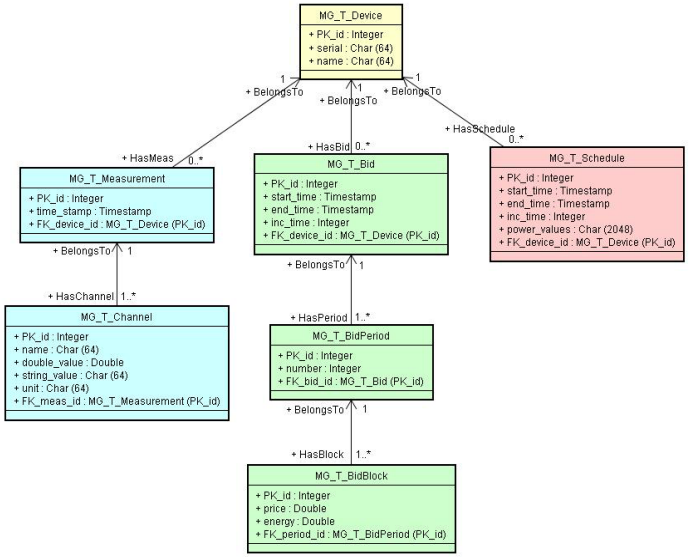
The MAS implementation

- The implementation was developed in Java
- The JADE (Java Agent DEvelopment Framework) platform was used. Jade simplifies the development of MAS and is FIPA compliant.
- One of the main features of Java is that is platform independent. Currently 2 PCs with Linux and 2 with Windows are used.

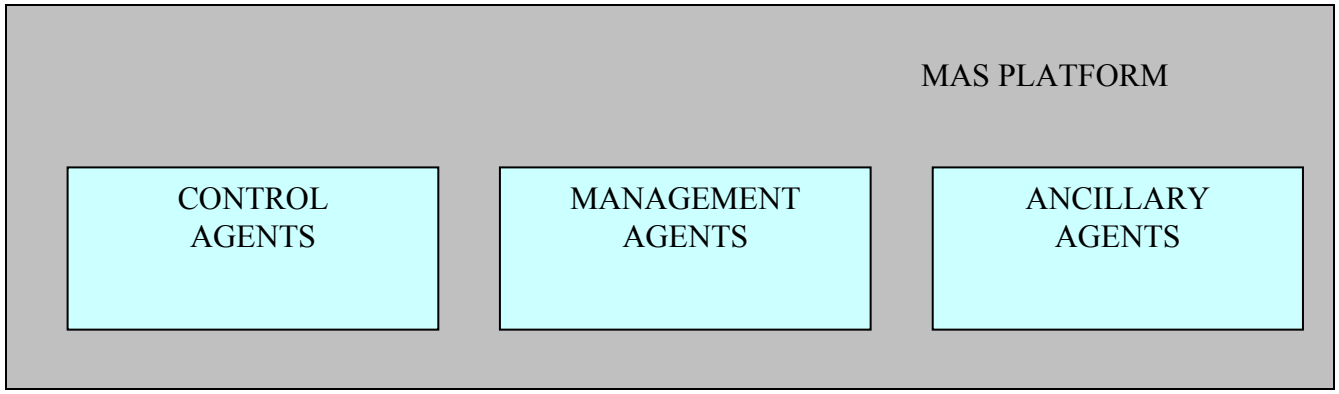
Ontology

The agents in order to communicate with each other should share the same ontology.

- Currently the ontology uses simple Concepts,Predicates and AgentActions for the system.



MAS perception



1. Control Agents: these agents control directly the physical units of the system.
2. Management Agents. These agents coordinate the MAS and take decisions regarding the state of it.
3. Ancillary Agents: these agents perform ancillary services like communication tasks or data storage.

Tasks of the MAS

- Production Unit Management-Control-Monitor.
- Load Control/Load Shedding.
- Market Operation.
- Black Start Operation.
- Voltage and Frequency Control in Isolated mode. Active-Reactive Power control in grid connected mode.
- Island transfer.

- On-going efforts concentrate on including **all these functionalities** inside the **same MAS**

Production Unit Management (I)

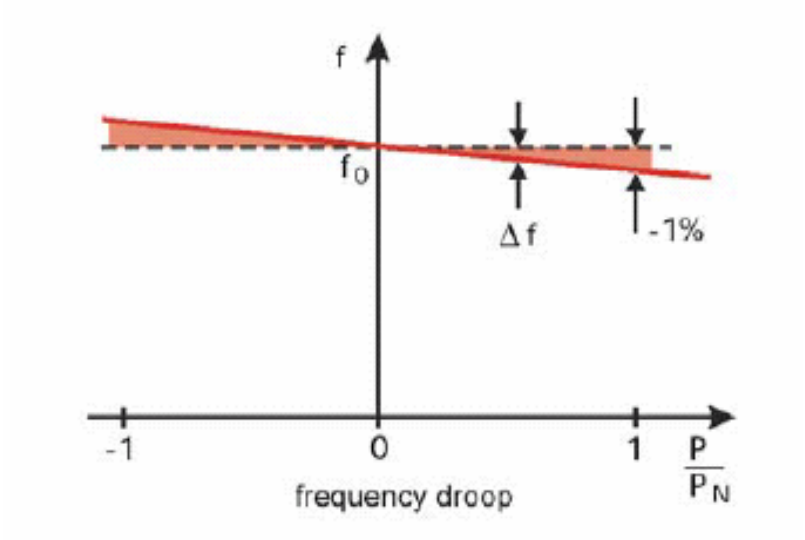
There are currently two production units

- A battery bank with an inverter which is fully controllable.
- A Photovoltaic Panel with an inverter which can be only monitored.

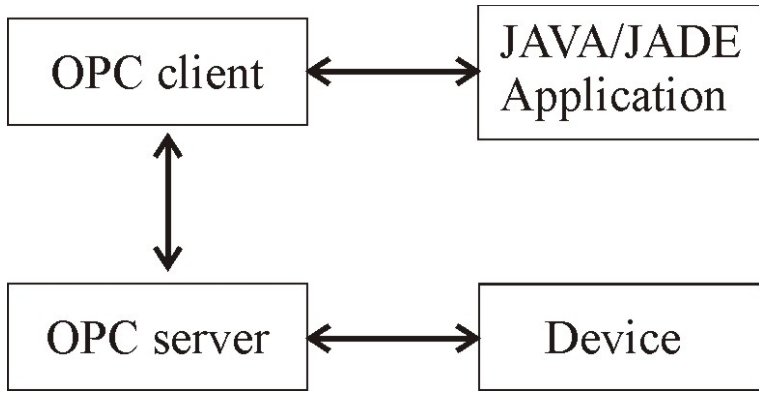
Production Unit Management (II)

Ex. For the battery inverter these tasks are held by the agents:

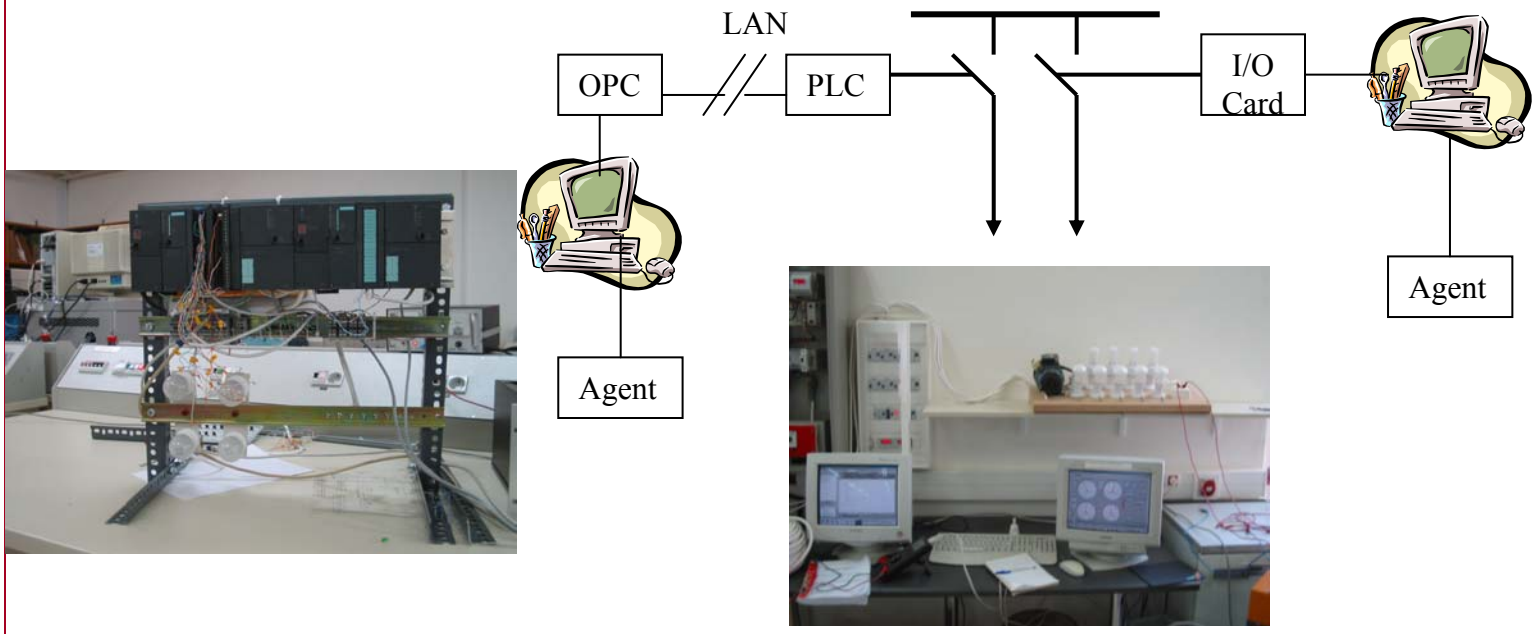
Control of the battery inverter



Communication of the agent with the battery inverter



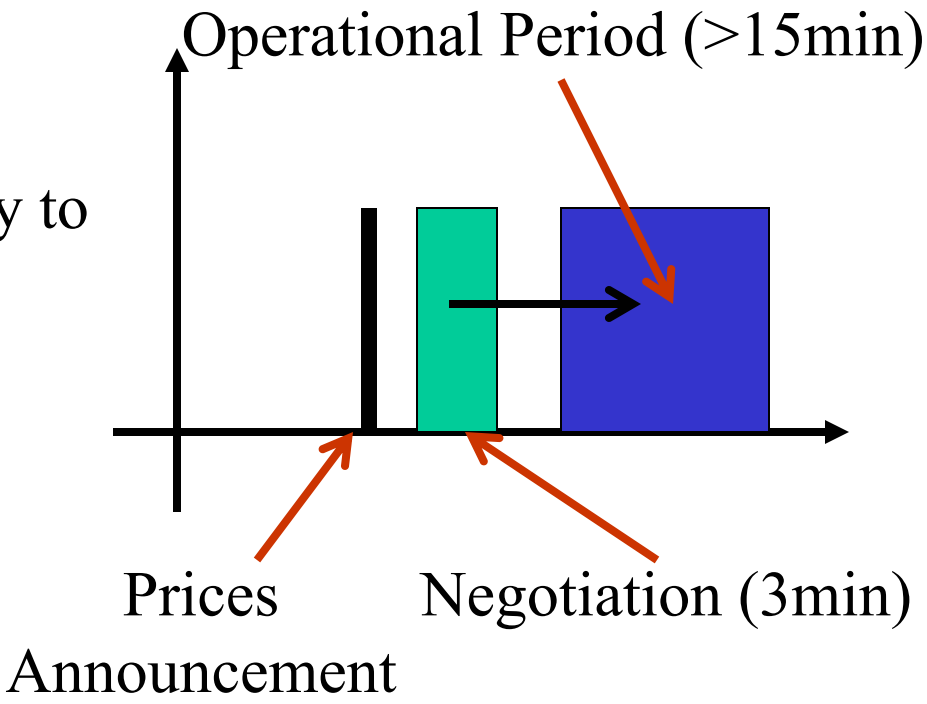
Load Control/Load Shedding



- One of the key features of the MAS system is the ability to control some of the loads of the Microgrid
- For the load shedding a simplified procedure is selected based on the fact that all loads have a predefined criticality factor and the nominal consumption is known.

Simple Market Operation of the Microgrid

1. The Grid Operator announces the prices for selling or buying energy to the MicroGrid.
2. The local loads keep making bids according to the English Auction Protocol for a specific time (3 minutes)
3. After the end of the negotiation time all the units know their set points



Simple Market Operation (II)

There are two main ways of market function:

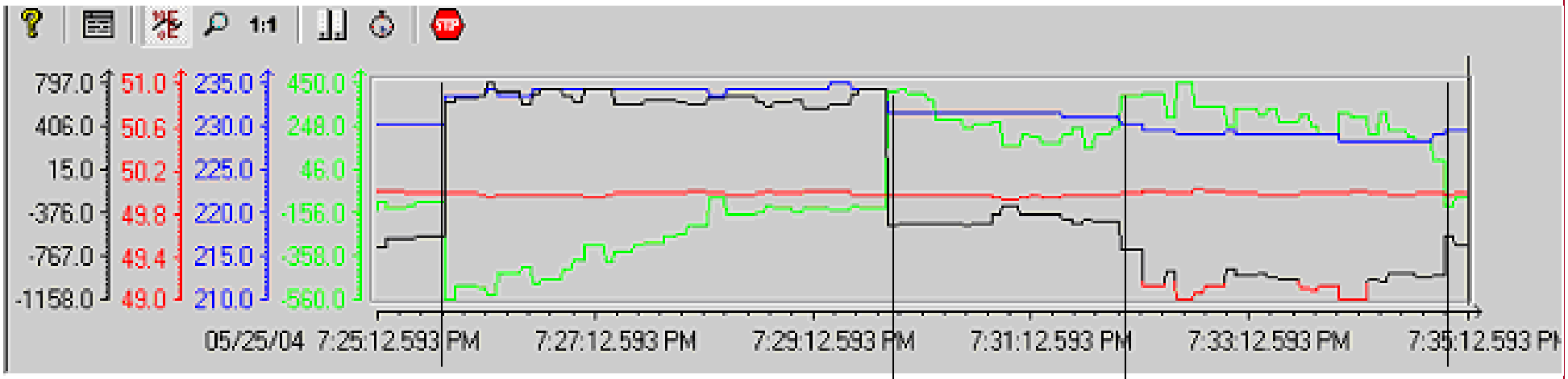
- The agents collaborate in order to maximize the benefit of the whole MicroGrid.
- Each agent tries to maximize his own gain.

It should be mentioned that gain is not necessarily the gain of the market:

Ex. A CHP unit tries to warm some local installation. This operation makes the unit an aggressive player during the winter and a passive one during the summer.

Active power Control

- Two set points of the inverter at 800W and –1000W.
- The interesting point in this measurement is that there is a voltage increase and decrease respectively. This is caused not only because of the reactive power consumption/production but also due to the high resistance of the cable (PQ coupling)

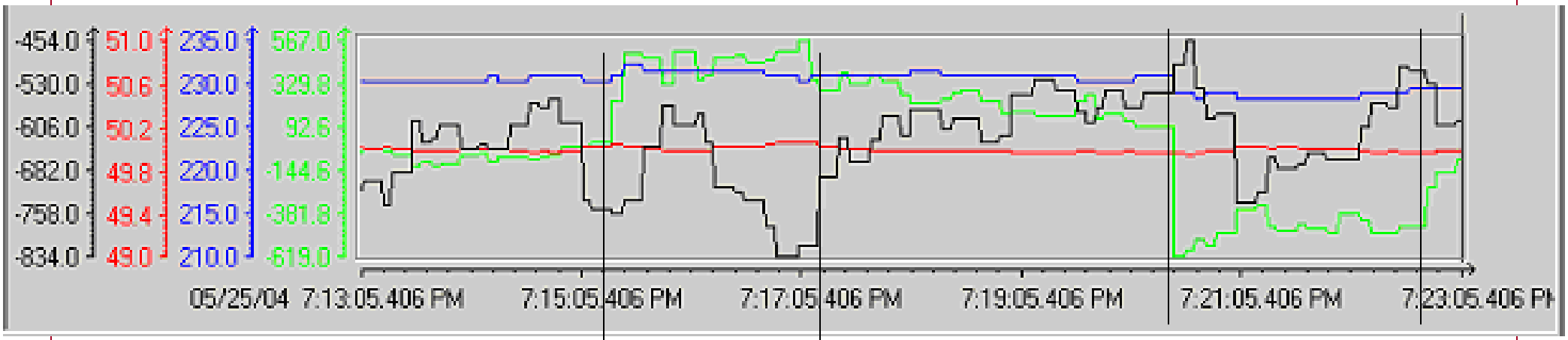


800 W set point

-1000 W set point

Reactive power Control

- Two set points at 500VAr and –500VAr.

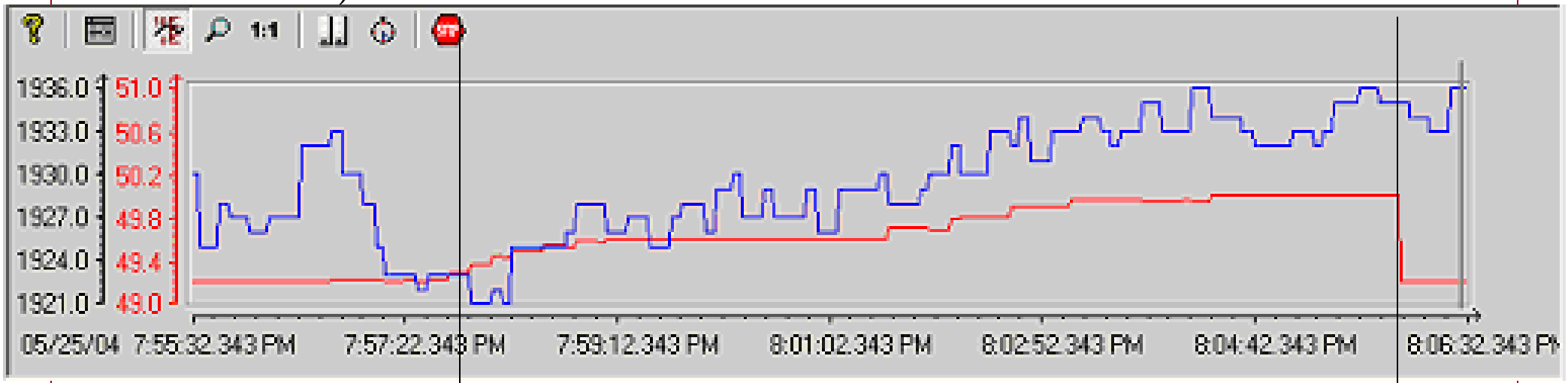


500 VAr set point

-500 VAr set point

Frequency Control

- The system is in island mode with a load of ~1900W.
- the inverter increases the frequency from 49.2Hz (no frequency Control) to 50Hz



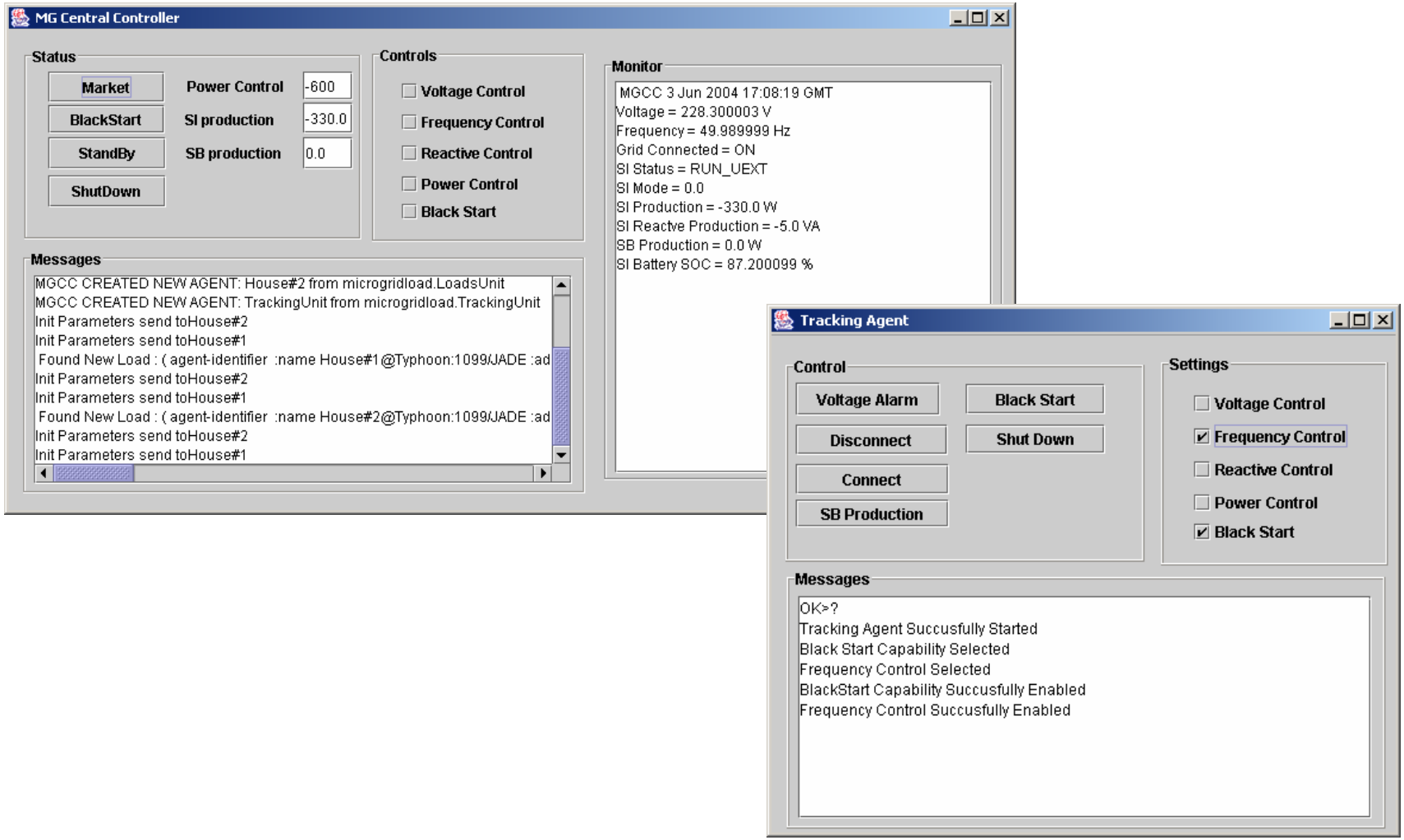
Frequency Control Start

Frequency Control Stop

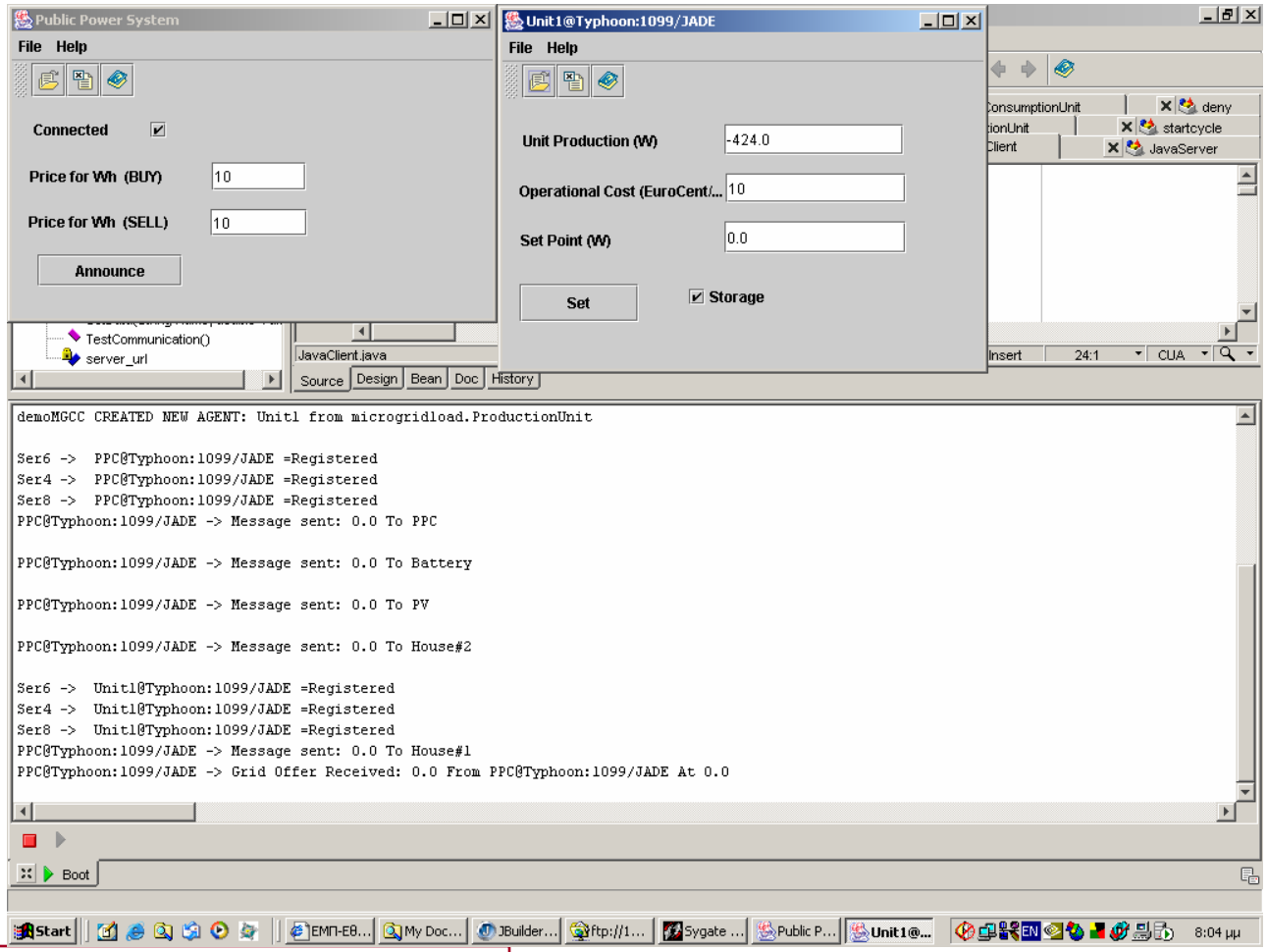
Islanding transfer

- Includes all the necessary actions that should be taken for the secure switch from Grid connected mode to island mode.
- The production should be adequate for a predefined period.
- At least one source with frequency and voltage control capabilities.
- Legal Framework.

Some frames (I)



Some frames (II)



Conclusions

- MAS for Microgrids operation
- The primary goal is to create “plug n’ play” DG systems.
- The MAS is tested on a laboratory system showing feasibility of application on actual microgrids.
- MAS satisfying many tasks, i.e. market participation, voltage and frequency control, seamless transfer to isolated mode, blackstart, etc. is possible.

Thank You

MicroGrids Project Web page:

http://microgrids.power.ece.ntua.gr