



## Simulation Approach for Energy Management in Wireless Sensor Networks

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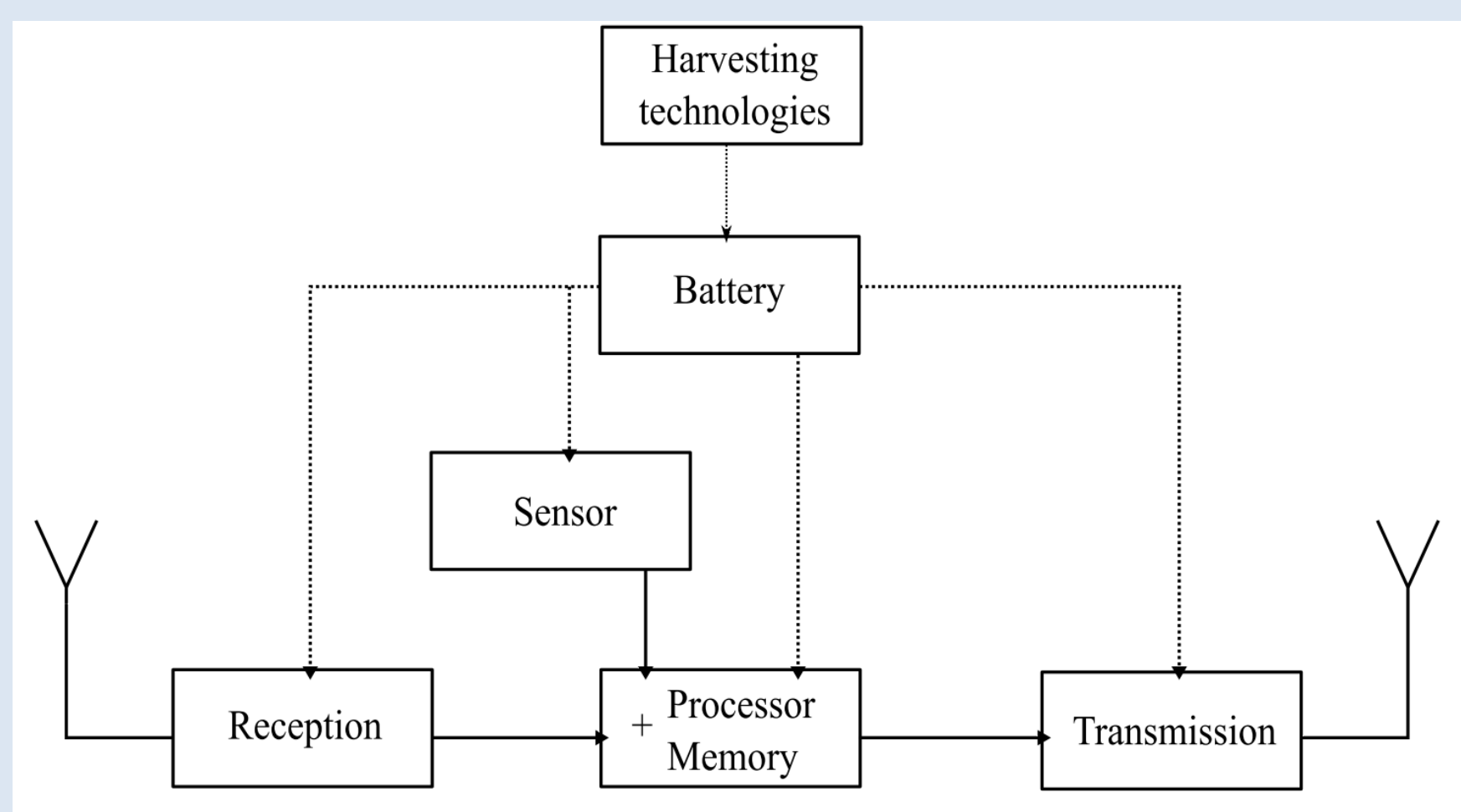
## Introduction

Sensor nodes are widely used in many applications :

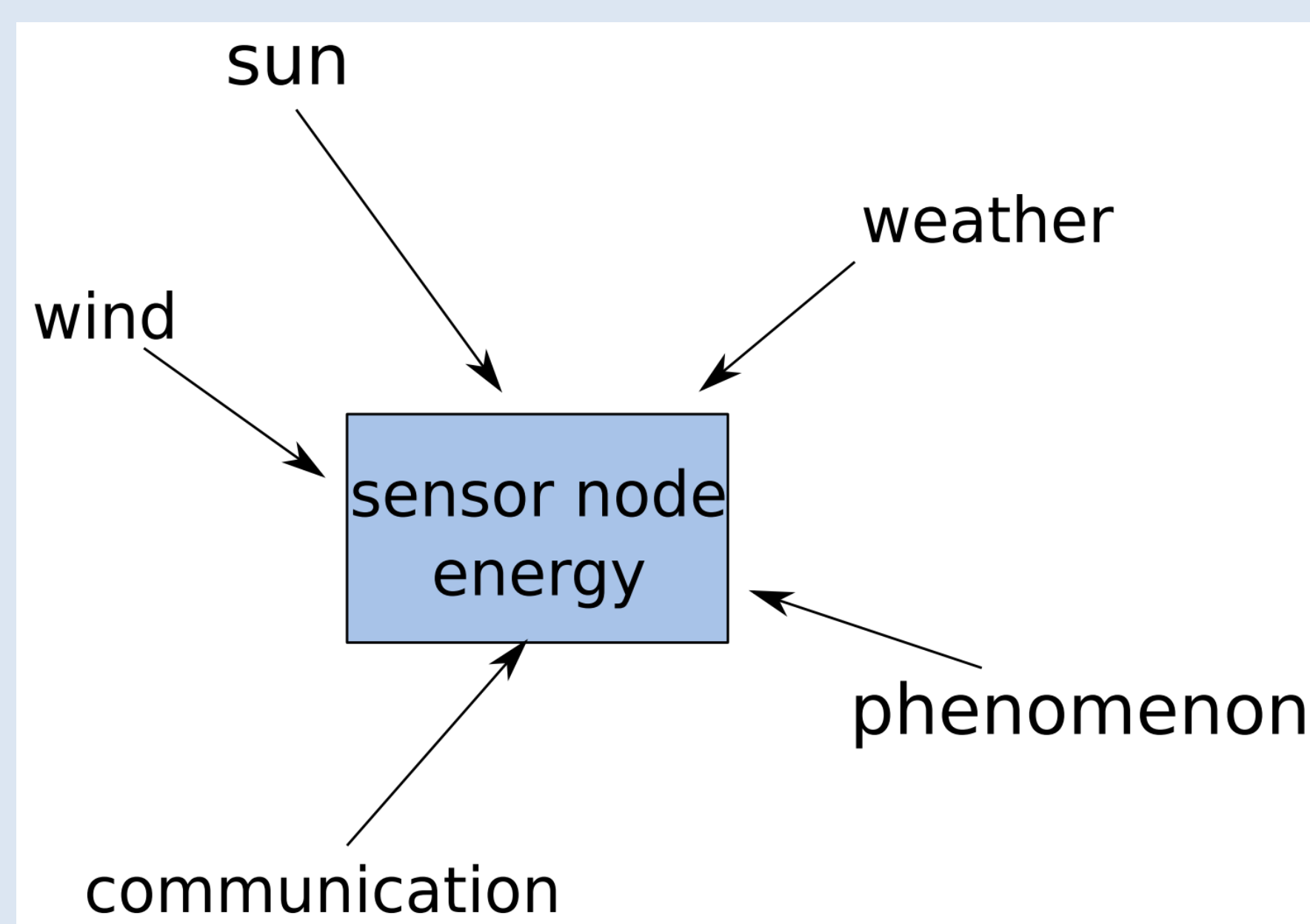
- Environmental monitoring
- Predictive maintenance
- Healthcare
- Smart grid
- Enhanced safety & security
- ...

Sensor nodes are composed of several unit. Modeling each component is hard and takes time.

### Main components of a sensor node

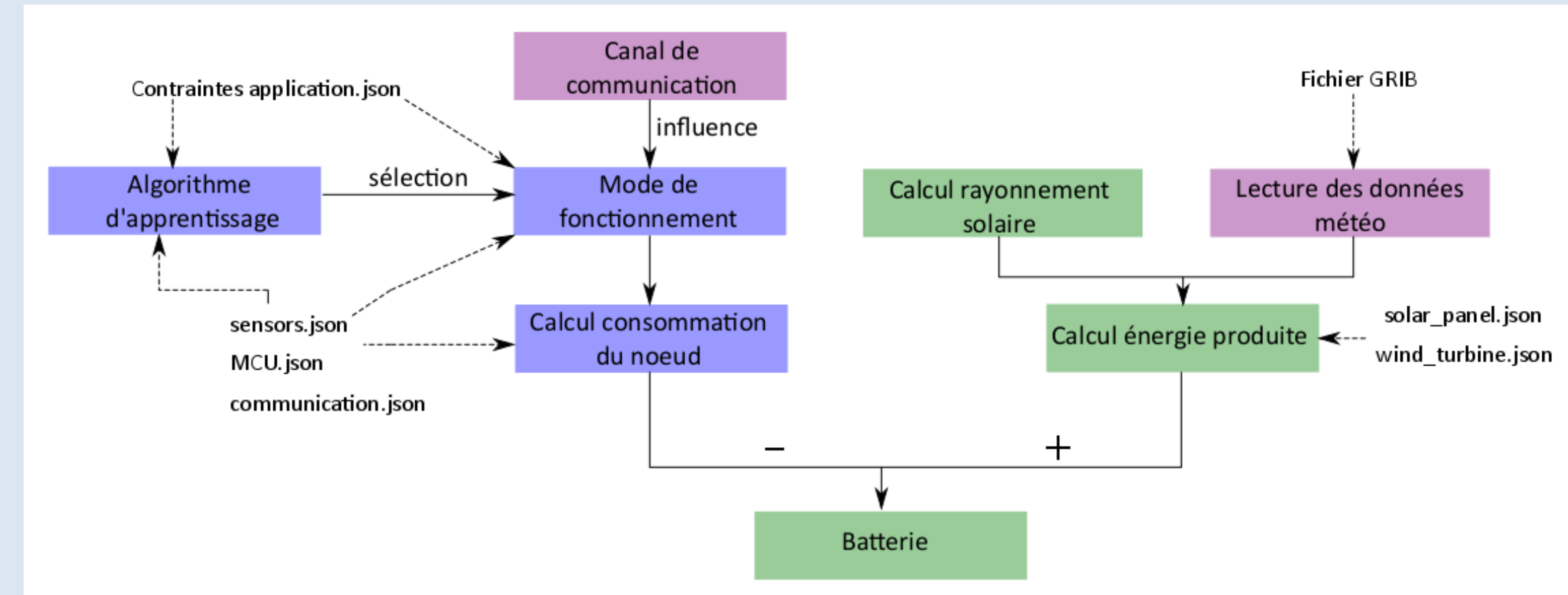


Moreover sensor nodes are deployed in stochastic environment which modifies their energy resources



**Energy consumption management**

## Simulator architecture



### Simulator parameters

Sensor node level simulator :

- Microprocessor
- Communication
- Sensors

Data sources :

- Manufacturers datasheet
- Grib meteo
  - Ambient temperature
  - Wind speed
- Solar radiation generation

Harvester & Energy storage models

- Wind turbine
- Solar panels
- Battery

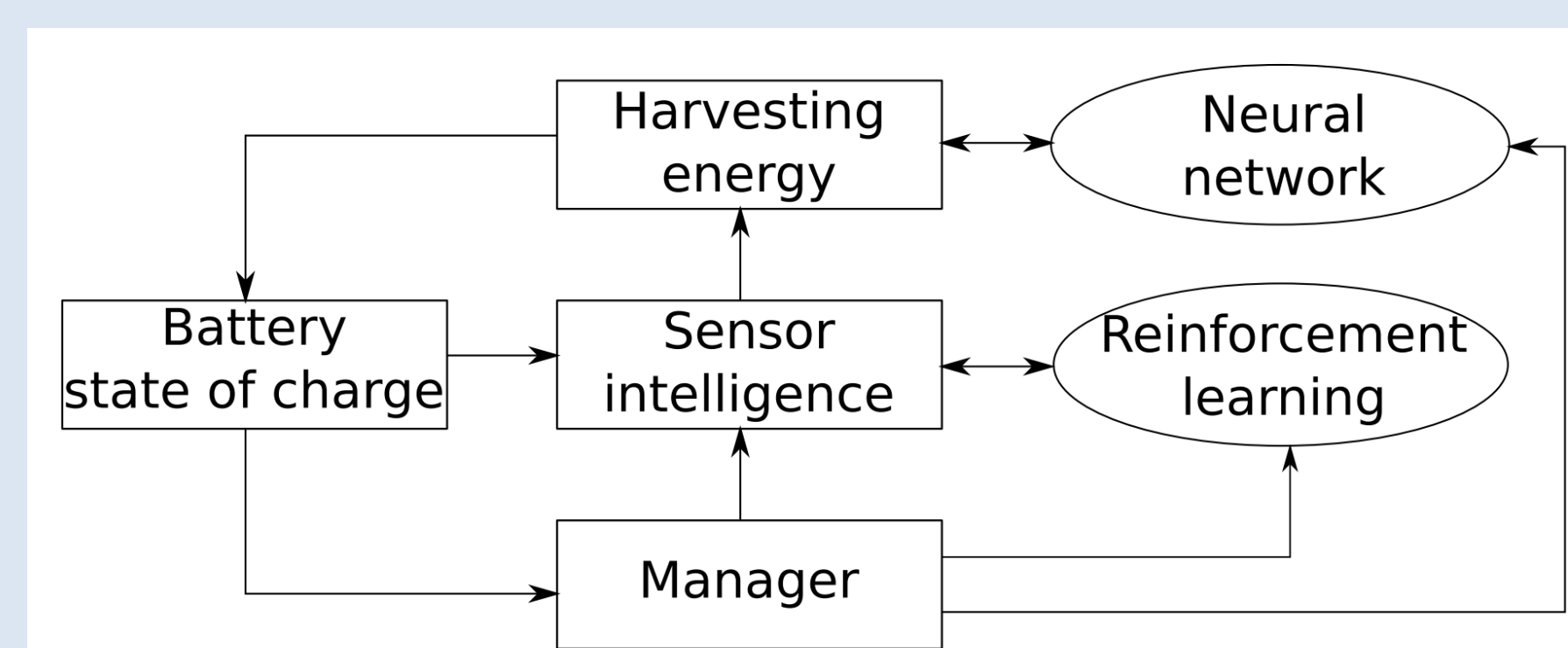
Others :

- Application constraints
- Energy management algorithm
- Geographical position of the node
- Deployment date & duration

## Objectifs

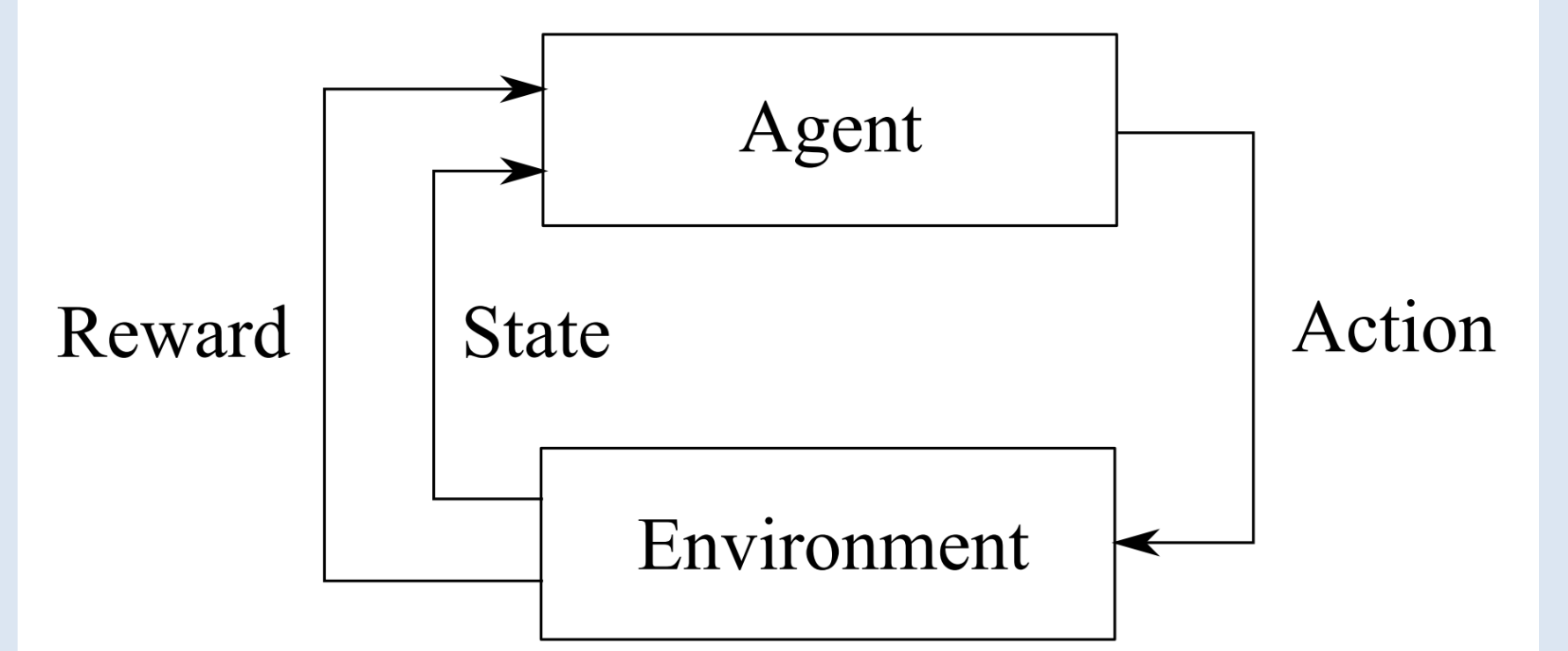
We want a self-management of energy by the sensor node. To make it work, we propose a hybrid solution based on two different approaches.

### An hybrid approach



- ➔ use neural networks to determine harvester model parameters
- ➔ use reinforcement learning to teach the node to manage its energy

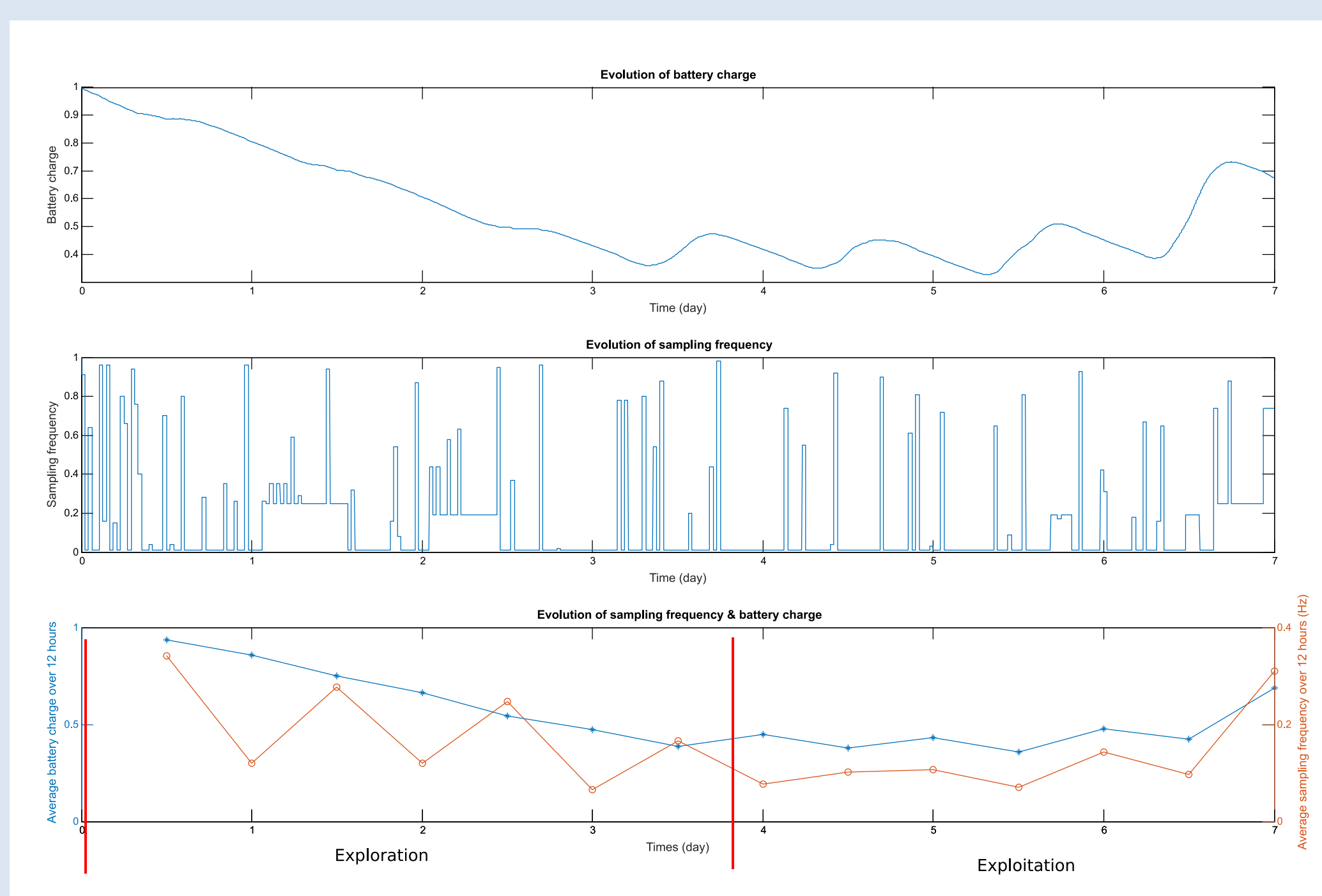
## Reinforcement learning



### Q-Learning algorithm

Initialize  $Q(s, a)$  arbitrarily  
 The agent observe the initial state  $s_0$   
 Initialize  $s$   
**for** each decision epochs **do**  
   Choose  $a$  from  $s$  using policy derived from  $Q$   
   Take action  $a$ , observe the new state  $s'$  and the associated reward  $r$   
    $Q(s, a) \leftarrow Q(s, a) + \alpha(r + \gamma \max_{a'} Q(s', a') - Q(s, a))$   
    $s \leftarrow s'$   
**end for**

## Results



### Q-Learning parameters

Parameter	Value
$\alpha$	0.1
$\gamma$	0.8
Time slot duration	30 minutes

### Sensor node's components

Components	Characteristic
Anemometers	WindMaster HS
Atmospheric sensor	YOUNG61302L
Processor unit	Cortex-M4 MCU
Communication unit	CC1000
Solar panel	$2 \times 10W$
Battery capacity	5200mA

## Conclusion

We presented a simulator used to test energy management algorithm and a approach to teach the node to manage itself its energy.

Some early results show that the node is able to self-manage its energy by adapting its sampling frequency.

### Future works

- ➔ Explore the control of other operating modes
- ➔ Teach the node to choose the computation it perform (data analysis, data compression, ...)