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SIMULATION APPROACH FOR ENERGY MANAGEMENT IN WIRELESS SENSOR NETWORKS

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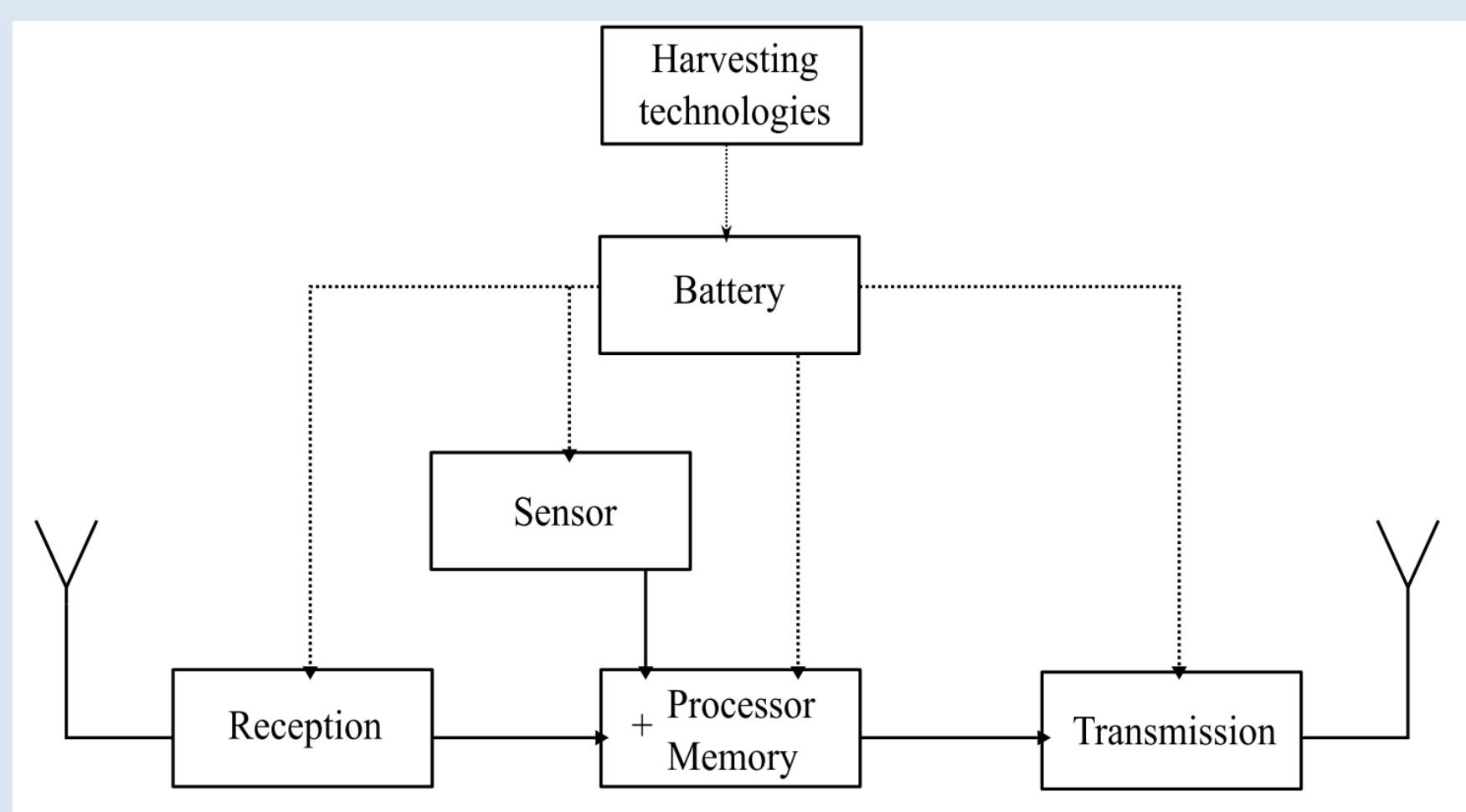
Introduction

Sensor nodes are widely used in many applications :

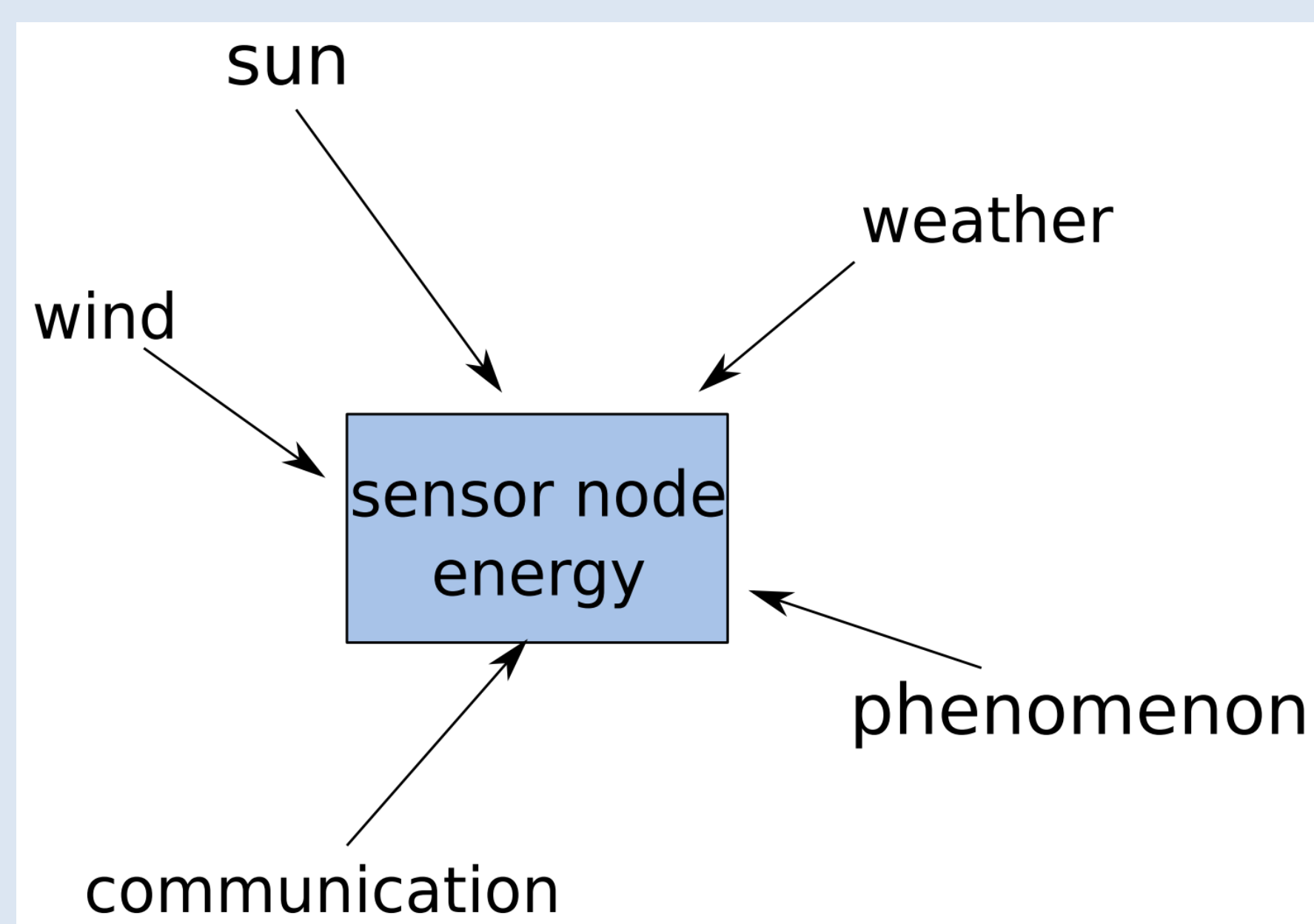
- Environmental monitoring
- Predictive maintenance
- Healthcare
- Smart grid
- Enhanced safety & security
- ...

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

Main components of a sensor node

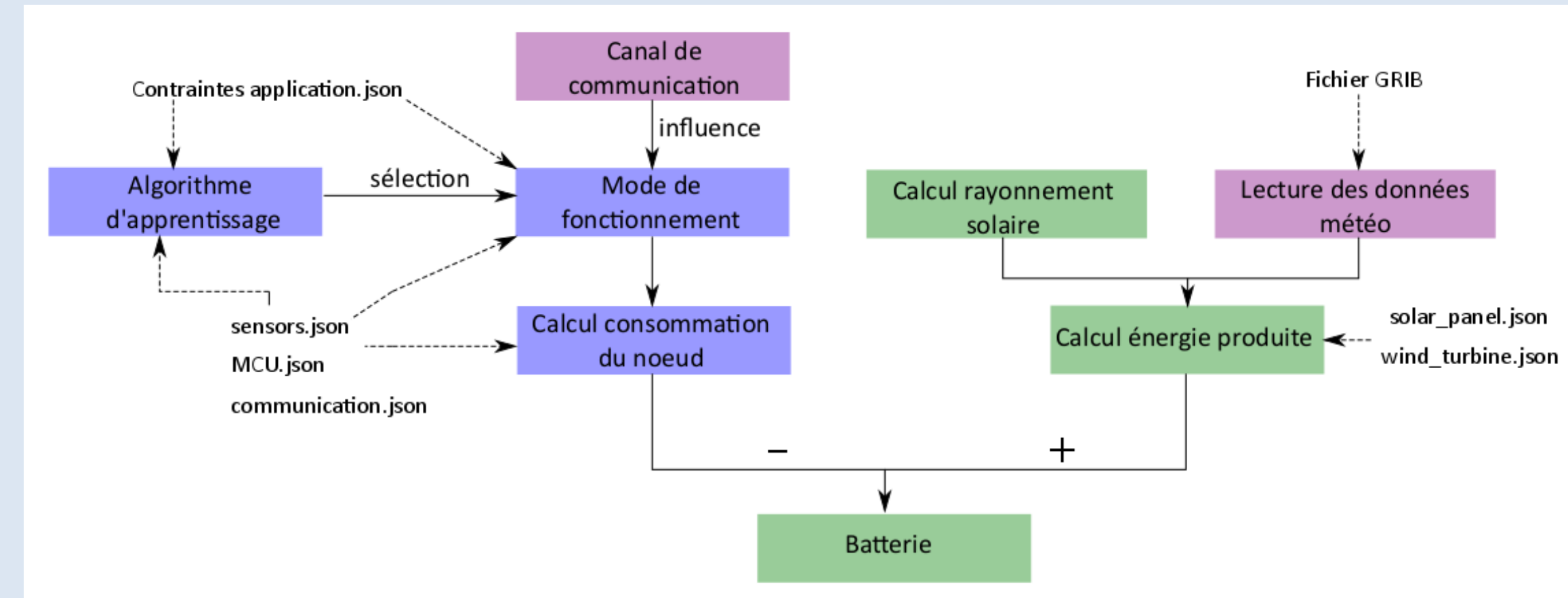


Moreover sensor nodes are deployed in stochastic environment which modifies their energy resources



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

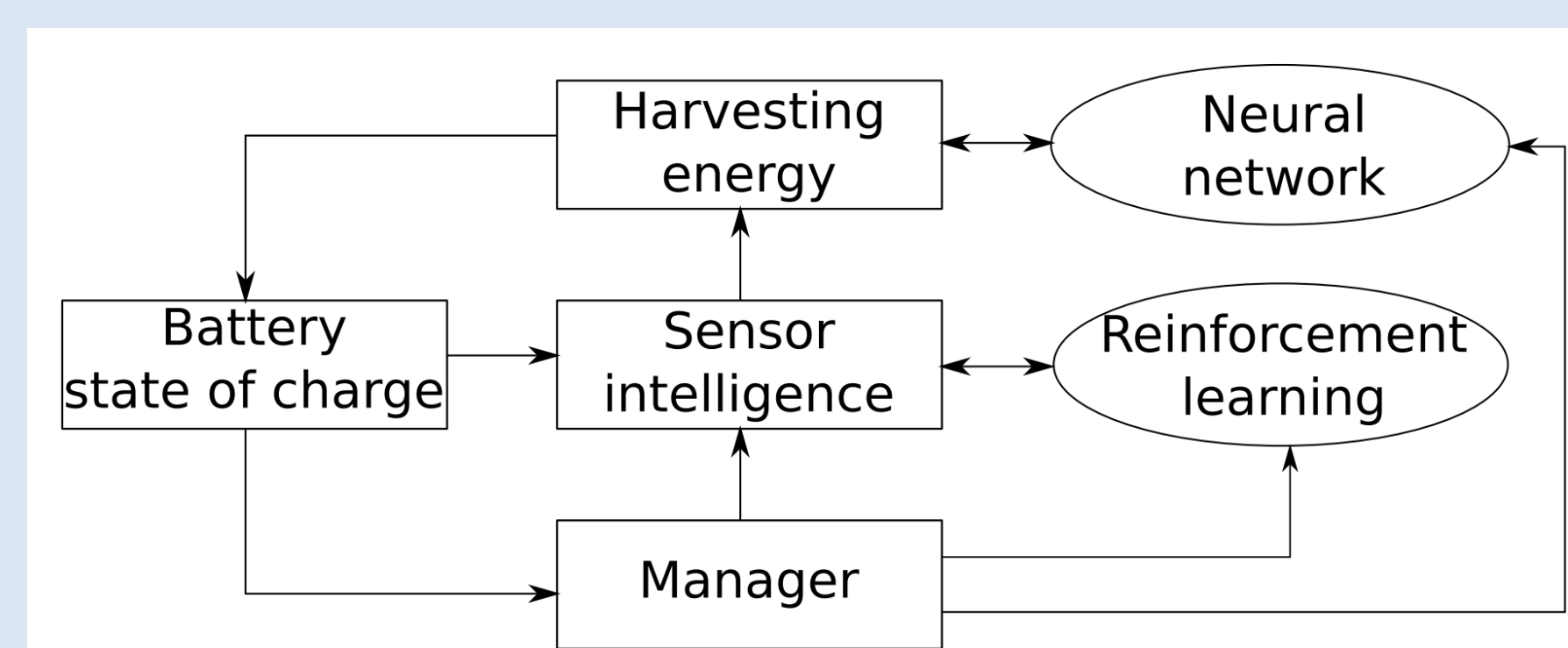
Others :

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

Objectifs

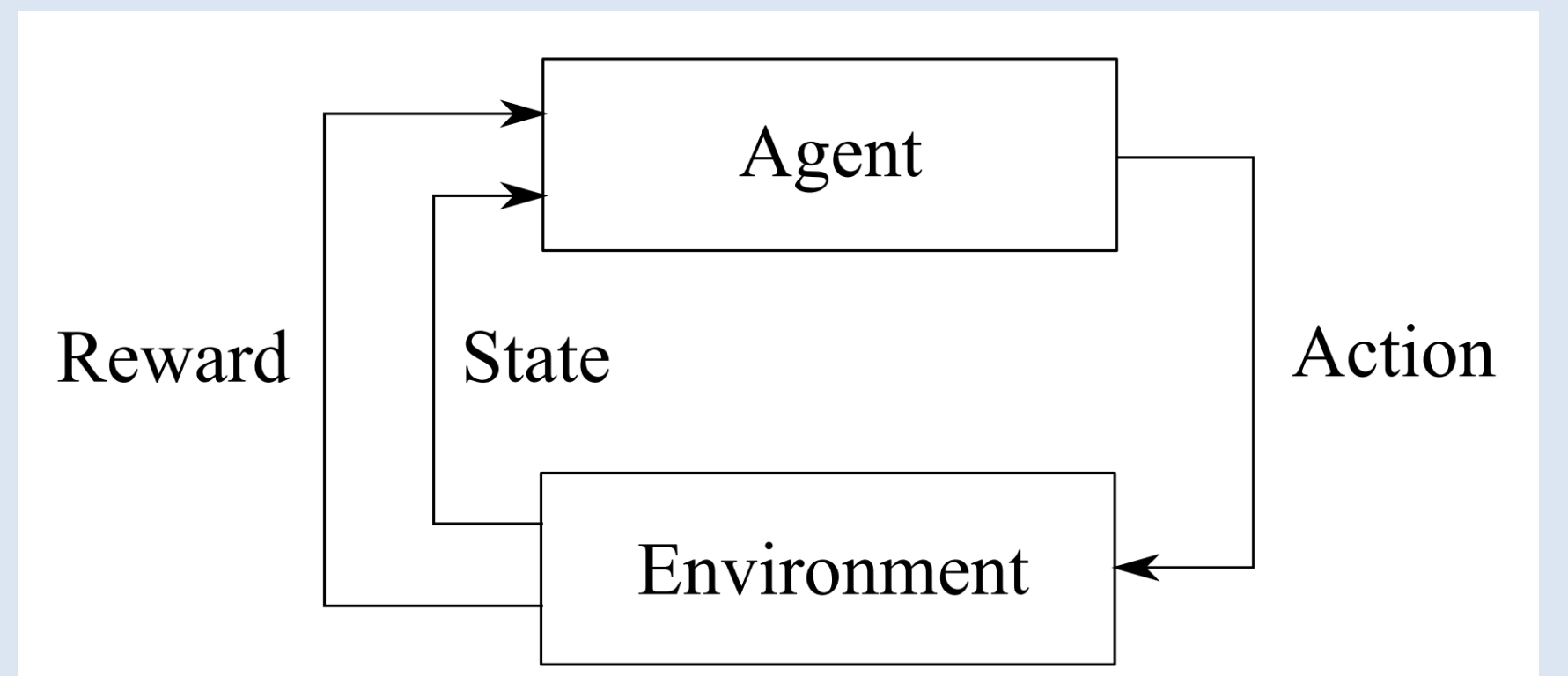
We want a self-management of energy by the sensor node. To make it work, we propose a hybrid solution based on two different approaches.

An hybrid approach



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

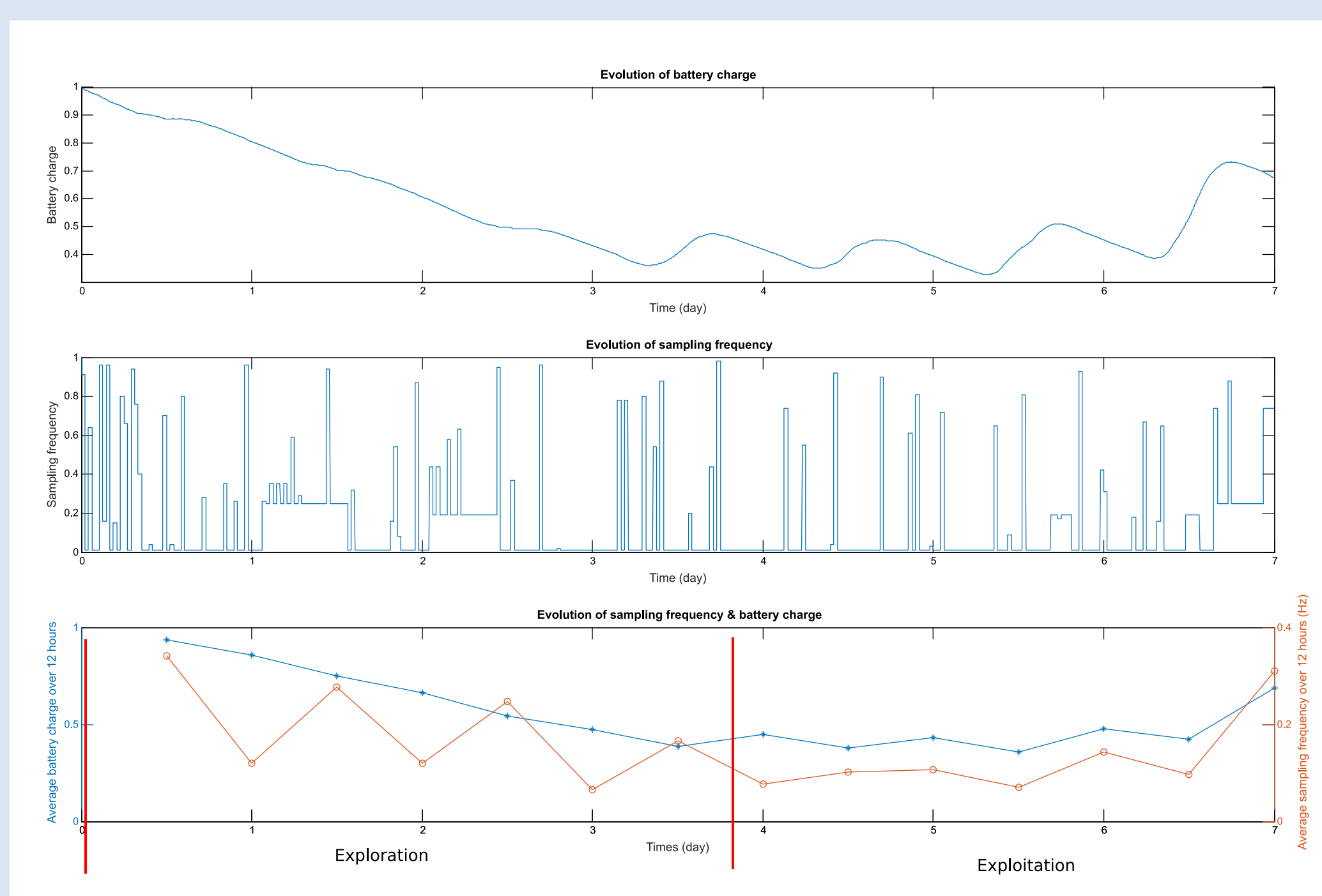
Reinforcement learning



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
α	0.1
γ	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 computationq it perform (data analysis, data compression, ...)