Machine Learning for Networking

Sampling in WSNs

Session 11 – Reducing the number of data tx

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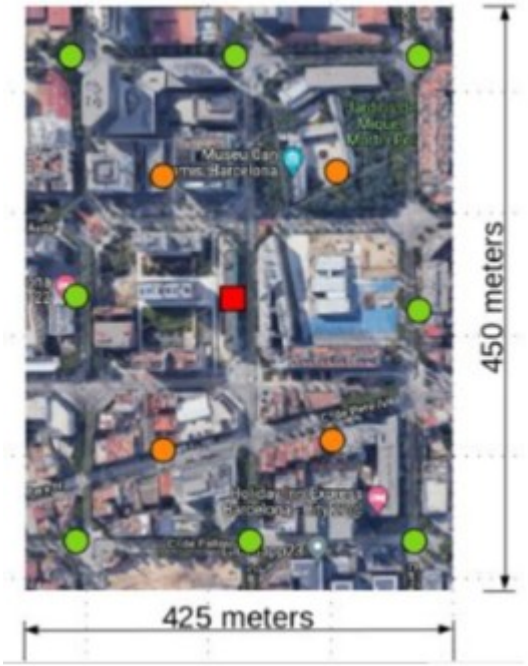
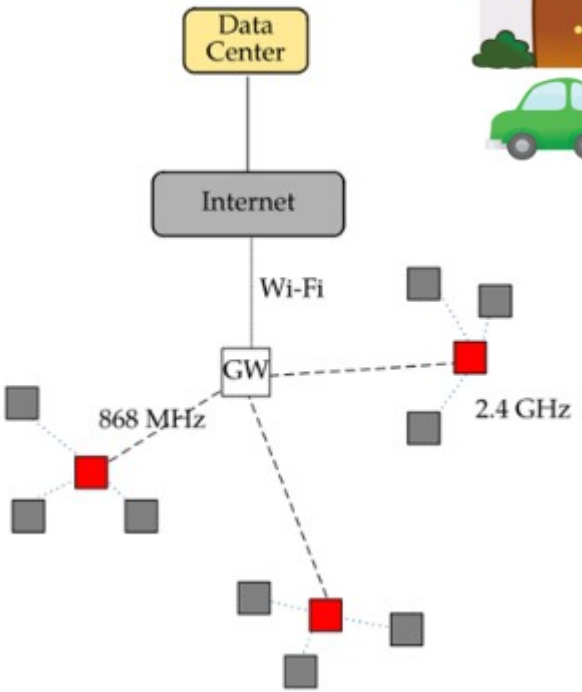
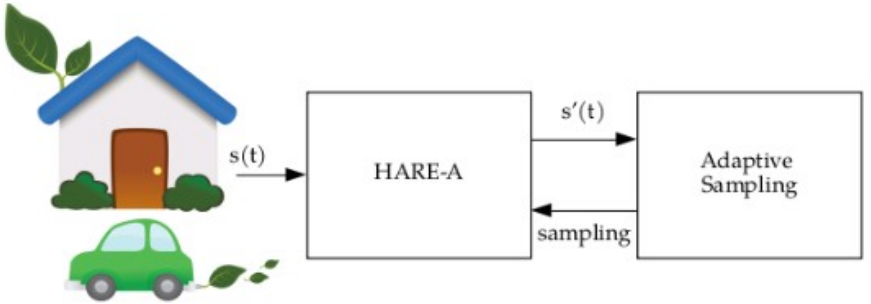
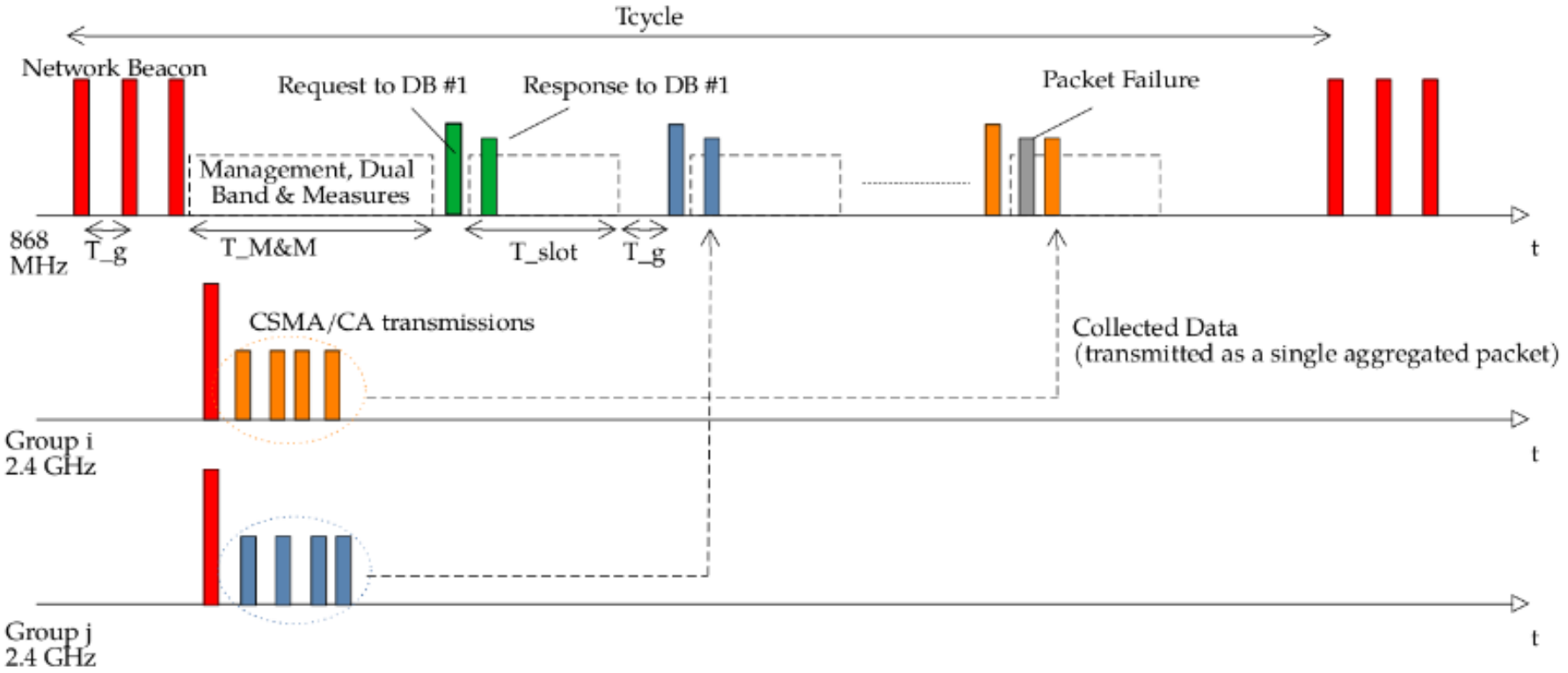
FEM-IoT Project







HARE-A


Tcycle
Network Beacon
Request to DB #1
Response to DB #1
Packet Failure
Management, Dual
Band & Measures
868
MHz
T_g
T_M&M
T_slot
T_g
t
CSMA/CA transmissions
Collected Data
(transmitted as a single aggregated packet)
Group i
2.4 GHz
t
Group j
2.4 GHz
t

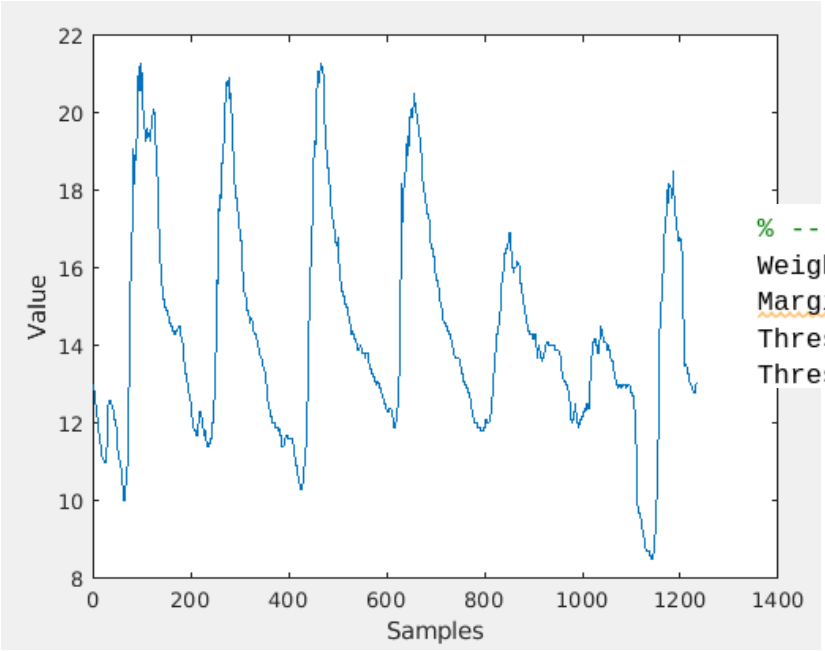
Adaptive Sampling

- Implemented in ThingSpeak!
- … and also in local, using a dataset (temperature, O3, CO2, etc)
- Adaptive sampling algorithms
  - Heuristic
  - MAB (epsilon greedy, Thompson Sampling)
  - Q-learning
- Motivation of Adaptive Sampling
  - Get always good results
  - Exploring / Learning may add overheads

Problem & Set-up

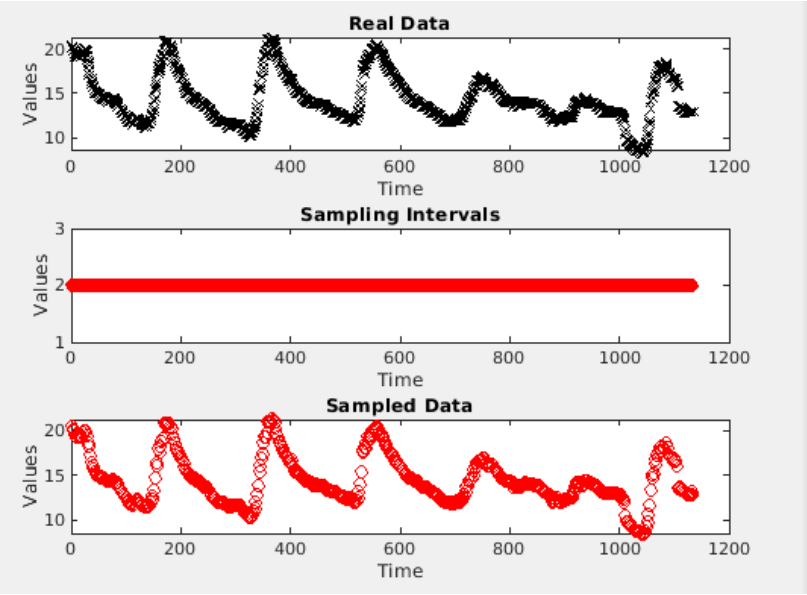
- Problem:
  - Track a ‘signal’ without any reference.
  - Trade-off between increasing sampling period and ability to detect changes on the signal.
- Set-up
  - 5 sampling periods: 6, 12, 18, 24, 30 mins
  - Quality metric: Accuracy + 0.5 x Fraction of samples avoided
  - A sample is ‘accurate’ if the difference with previous sample is below a certain ‘threshold’.
  - This threshold is computed taking into account the own ‘noise / variance’ of the signal.

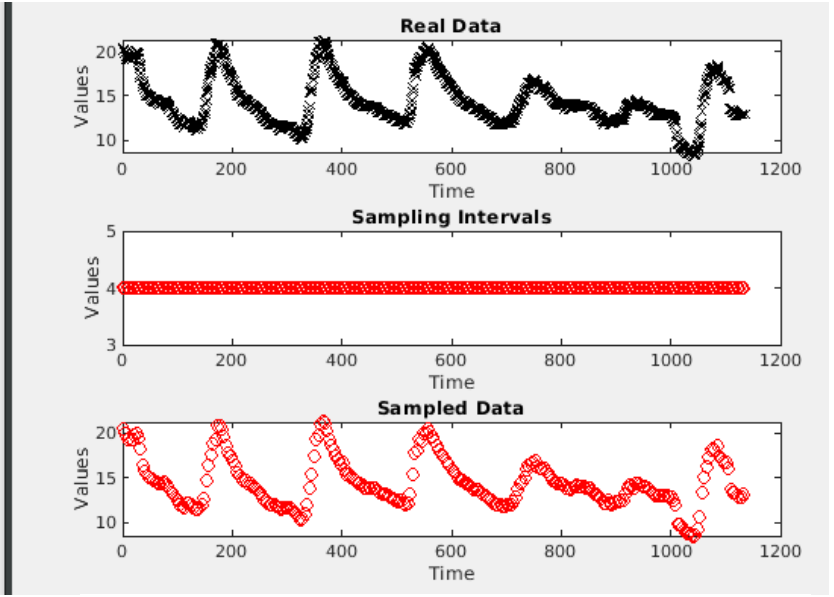
Threshold




```
% ---- Initial training (std. dev. estimation, and threshold setup) ----
Weight=2.5; % Design Parameter
Margin=0; % Design Parameter
ThresholdLow = Weight*mean(abs(diff(data_stream_training)));
ThresholdHigh = ThresholdLow + 0;
```

Constant sampling period

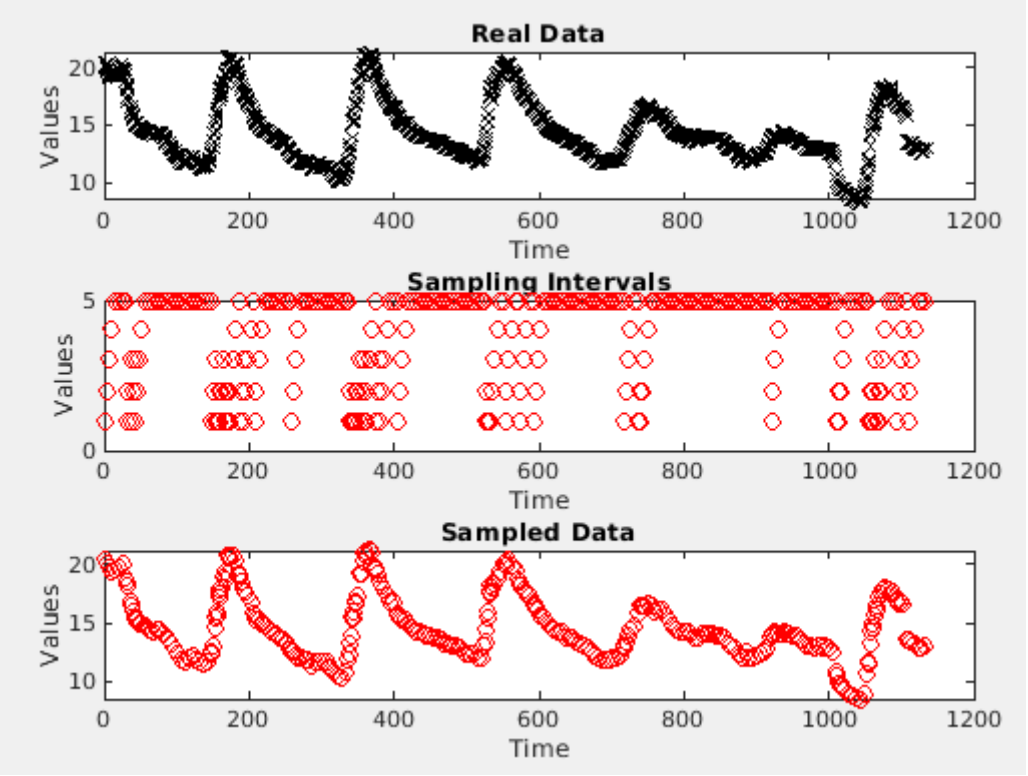





```
SP=2
################ RESULTS ################
--- Thresholds ---
   5.5051e-01   5.5051e-01

Successful Samplings | Av. Successful Samplings
   5.2800e+02   9.3122e-01

Total Number Samples | Real Number Samples | Savings (%)
        1134         567          50

Joint Metric: Accuracy + savings
   1.1812e+00
```

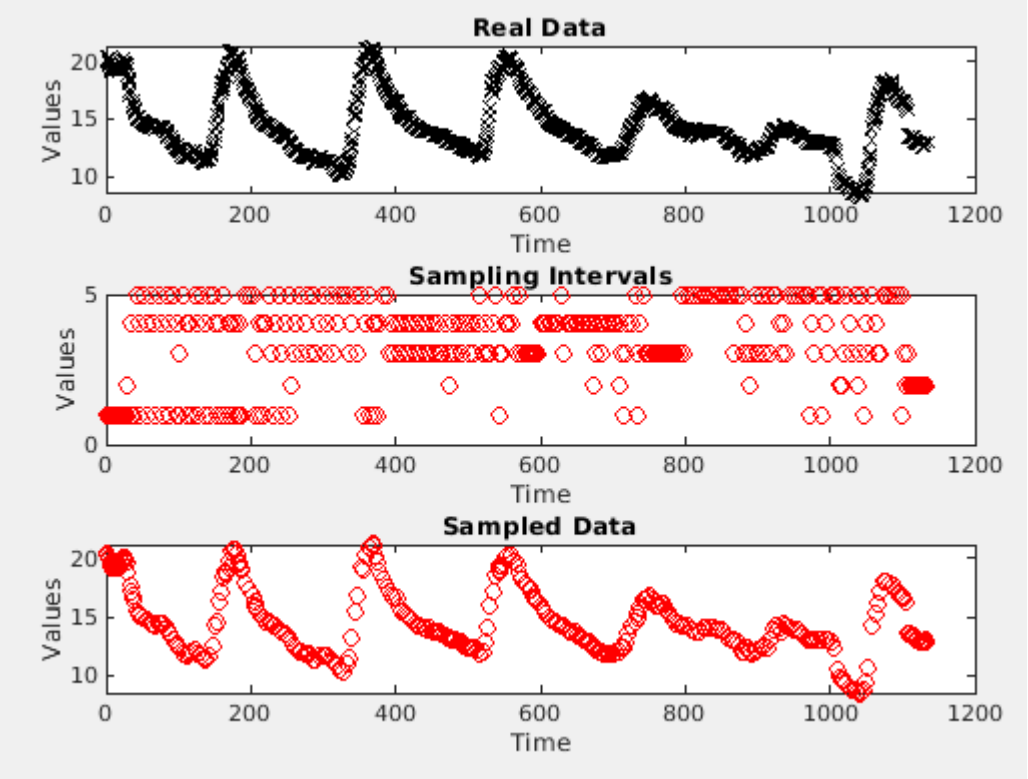
```
SP=4
################ RESULTS ################
--- Thresholds ---
   5.5051e-01   5.5051e-01

Successful Samplings | Av. Successful Samplings
   2.2800e+02   8.0282e-01

Total Number Samples | Real Number Samples | Savings (%)
   1.1340e+03   2.8400e+02   7.4956e+01

Joint Metric: Accuracy + savings
   1.1776e+00
```

Heuristic Algorithm




```
AS
################ RESULTS ################
--- Thresholds ---
   5.5051e-01   5.5051e-01

Successful Samplings | Av. Successful Samplings
   2.5600e+02   8.3117e-01

Total Number Samples | Real Number Samples | Savings (%)
   1.1340e+03   3.0800e+02   7.2840e+01

Joint Metric: Accuracy + savings
   1.1954e+00
```

Q-learning

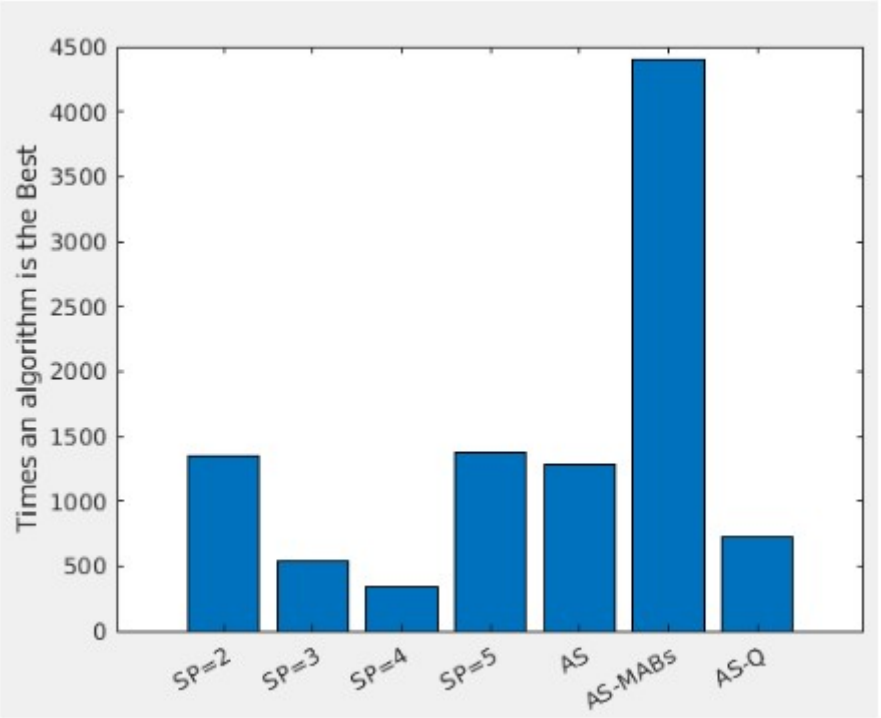


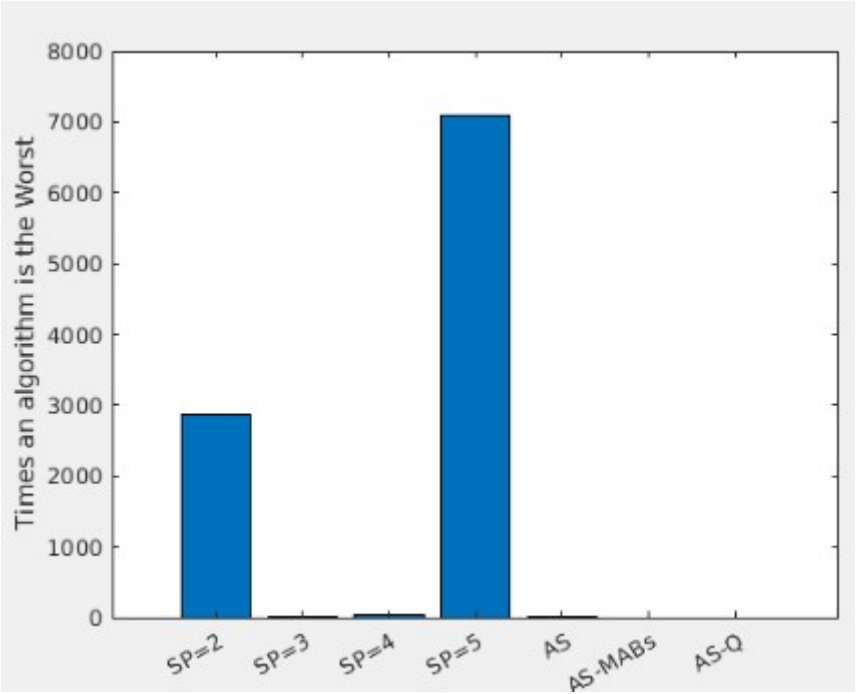

```
AS-Q
################## RESULTS #################
--- Thresholds ---
   5.5051e-01   5.5051e-01

Successful Samplings | Av. Successful Samplings
   3.0100e+02   8.5755e-01

Total Number Samples | Real Number Samples | Savings (%)
   1.1340e+03   3.5100e+02   6.9048e+01

Joint Metric: Accuracy + savings
   1.2028e+00
```

Activity

- Download the code (Example11.zip)
- Execute *SamplingSimulationFemIoT.m*
- Test different 'heuristic policies' → Can you design a better heuristic solution?
- Implement MAB epsilon greedy, and compare with previous results
- Test other 'streams' from the dataset

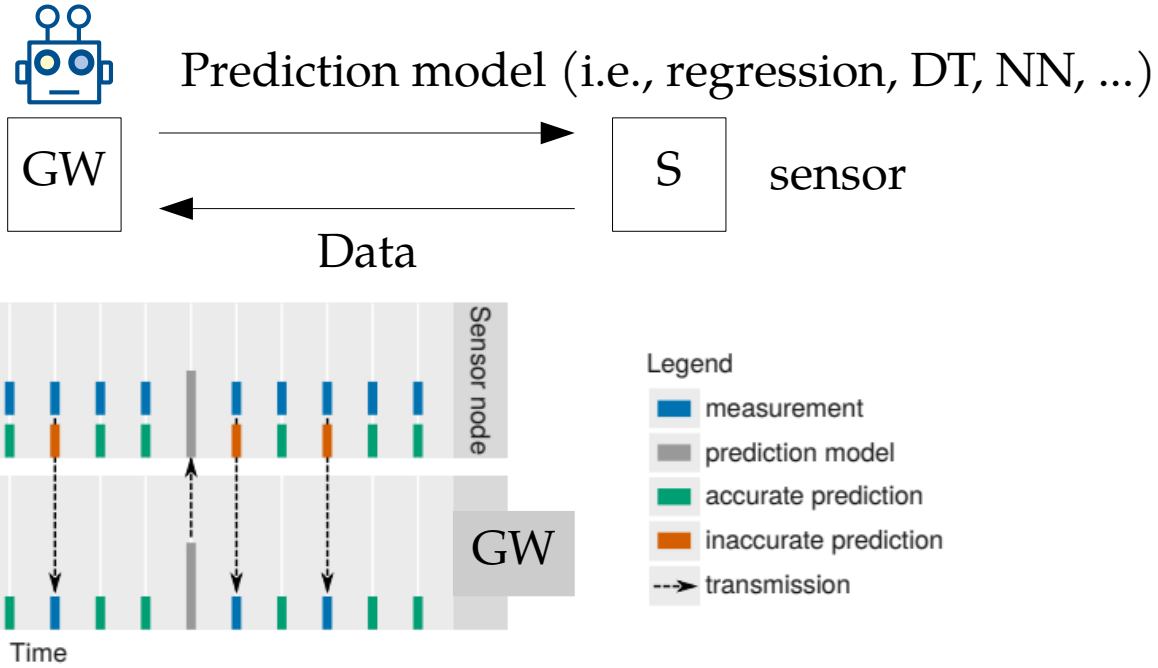
Comparative (10000 simulations)





Suggested Reading – Making Predictions

- Dias, G.M., Bellalta, B. and Oechsner, S., 2016. **A survey about prediction-based data reduction in wireless sensor networks.** ACM Computing Surveys (CSUR), 49(3), pp.1-35. [link]




The end