LIGHTWEIGHT NETWORK INTERFACE SELECTION FOR IOT

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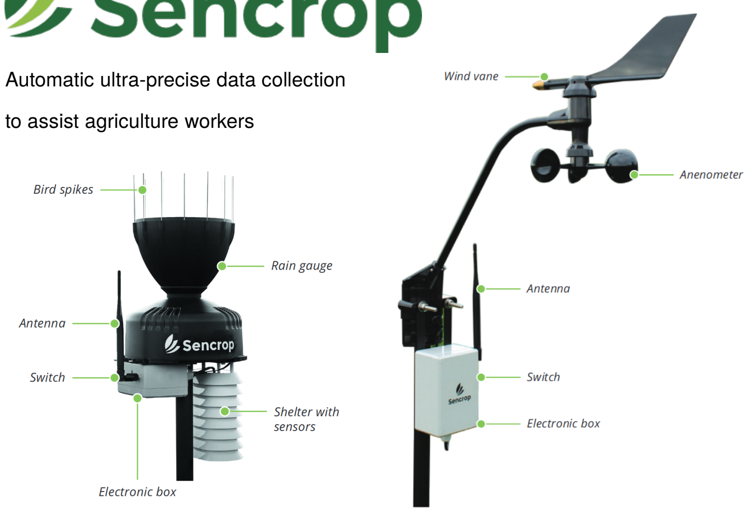
Future ubiquitous networks

CONTEXT

Sencrop

Automatic ultra-precise data collection to assist agriculture workers



[1] Sencrop. Url: https://sencrop.com/.

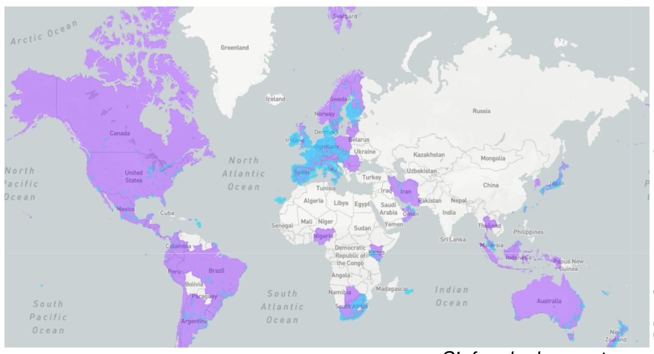
Goal: Extend geographical range of operation & over-the-air firmware updates

sigfox

100 bytes per second

140 x 12 bytes / day upstream

4 x 8 bytes / day downstream



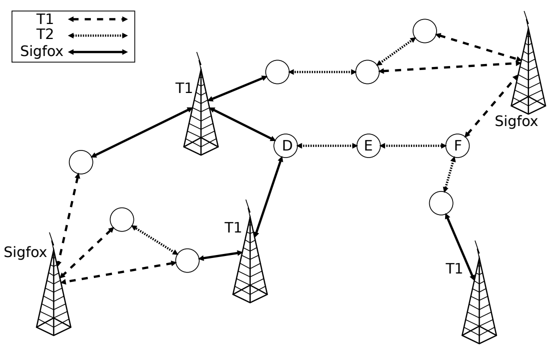
Sigfox deployment map

[2] Sigfox coverage map. Url: https://www.sigfox.com/en/coverage.

Idea: Multiple radio technologies & multi-hop networks

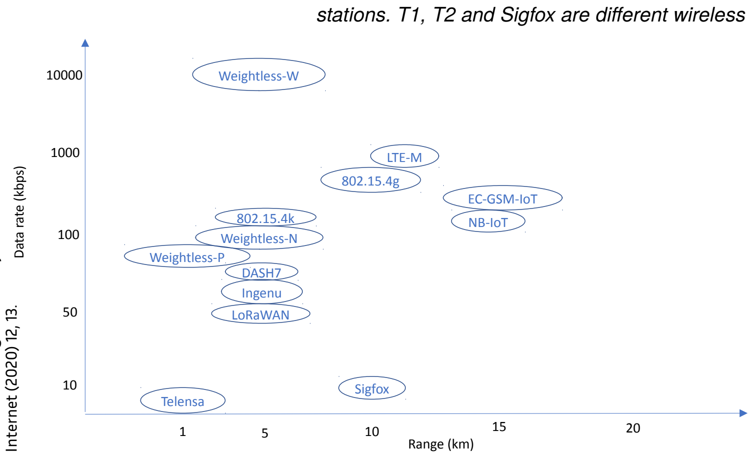
MULTI TECH STATIONS

- Each station has access to several wireless radio technologies
- Stations can relay communications from in range stations



Multi-hop multi-technology network. D, E and F are weather stations. T1, T2 and Sigfox are different wireless technologies

[3] B. Foubert, N. Mitton. "Autonomous Collaborative Wireless Weather Stations: A Helping Hand for Farmers". In: ERCIM News 119 (2019), pp. 37-38.



[4] B. Foubert, N. Mitton. "Long-Range Wireless Radio Technologies: A Survey". In: MDPI Future Internet (2020) 12, 13.

Many different technologies exist, with various attributes and performances

How can a station choose which tech is the best one for a given use case or scenario ?

NETWORK INTERFACE SELECTION

	P_1 w_1	P_2 w_2	...	P_m w_m
A_1	x_{11}	x_{12}	...	x_{1m}
A_2	x_{21}	x_{22}	...	x_{2m}
...	...	...	...	...
A_n	x_{n1}	x_{n2}	...	x_{nm}

Multi Attribute Decision Making (MADM) matrix

MADM problem

- A = {Ai, for i=1,2,...,n} the set of candidates
- P = {Pj, for j=1,2,...,m} the set of attributes
- w1, w2, ..., wm the weights of each attribute

TOPSIS

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}}$$

Normalization

$$v_{ij} = w_j r_{ij} \ where \ \sum_{j=1}^{n} w_j = 1$$

Weighting

$$A^+ = [v_1^+ ... v_m^+] \ and \ A^- = [v_1^- ... v_m^-]$$

Ideal solutions determination

$$v_j^+ = max\{v_{ij}, i = 1, ..., n\}$$
$$v_j^- = min\{v_{ij}, i = 1, ..., n\}$$

Best & worst values determination

$$v_j^+ = min\{v_{ij}, i = 1, ..., n\}$$
$$v_j^- = max\{v_{ij}, i = 1, ..., n\}$$

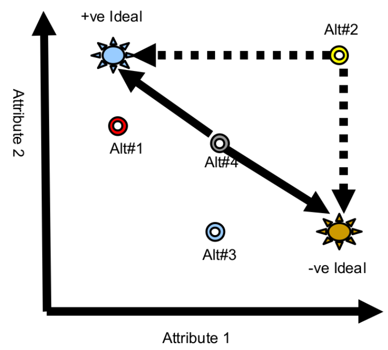
$$S_i^+ = \sqrt{\sum_{j=1}^{m} (v_j^+ - v_{ij})^2}$$
$$S_i^- = \sqrt{\sum_{j=1}^{m} (v_j^- - v_{ij})^2}$$

Distances calculation

$$C_{TOPSIS} = \frac{S_i^-}{S_i - + S_i^+}$$

Relative closeness calculation

The highest is the winner



Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

[5] F. Bari and V. Leung, "Multi-Attribute Network Selection by Iterative TOPSIS for Heterogeneous Wireless Access," 2007 4th IEEE Consumer Communications and Networking Conference, Las Vegas, NV, 2007, pp. 808-812

Ranking instability

- Alteration of the final ranking when removing worst candidates
- Caused by standard normalization
- Using alternative normalization methods can reduce the effect but cannot neutralize it [6]

Issues: Complex calculations & ranking abnormalities

LIGHTWEIGHT TOPSIS

Lightweight normalization

```
Require: x_ij the raw value of each attribute j for each candidate i
  for each attribute P_j do
    if P_j is an upward attribute then
      B_j^+ is the upper bound of P_j
      r_ij = x_ij / B_j^+
    else if P_j is a downward attribute then
      B_j^- is the lower bound of P_j
      r_ij = B_j^- / x_ij
    end if
  end for
  return r_ij the normalized value of x_ij
```

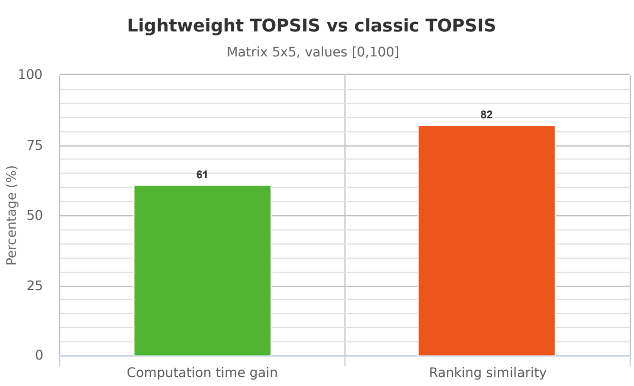
$$S_i^+ = \sqrt{\sum_{j=1}^{m} v_{ij}^2}$$
$$S_i^- = \sqrt{\sum_{j=1}^{m} (v_{ij} - 1)^2}$$

Lightweight distances calculation

Simple and stable normalization

- Reduce complexity and eliminate rank reversal
- Application layer expresses needs in terms of bounds and weights
- Use fixed bounds for each attribute

EXPERIMENTS



[7] Pycom FiPy. Url: https://pycom.io/product/fipy/

- Pycom FiPy with five network interfaces
- MicroPython implementation
- Ranking performances comparison

REFERENCES

[1] Sencrop. Url: https://sencrop.com/.
[2] Sigfox coverage map. Url: https://www.sigfox.com/en/coverage.
[3] B. Foubert, N. Mitton. "Autonomous Collaborative Wireless Weather Stations: A Helping Hand for Farmers". In: ERCIM News 119 (2019), pp. 37-38.
[4] B. Foubert, N. Mitton. "Long-Range Wireless Radio Technologies: A Survey". In: MDPI Future Internet (2020) 12, 13.
[5] F. Bari and V. Leung, "Multi-Attribute Network Selection by Iterative TOPSIS for Heterogeneous Wireless Access," 2007 4th IEEE Consumer Communications and Networking Conference, Las Vegas, NV, 2007, pp. 808-812
[6] Senouci, M. (2018). Sélection adaptative de la technologie réseau pour le transport de données dépendant du contexte (Doctoral dissertation, Paris Est).
[7] Pycom FiPy. Url: https://pycom.io/product/fipy/

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