Outline

1. Genetic Algorithm For LoRa Transmission Parameter Selection

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- Parameters
  - Bandwidth (*BW*)
  - Spreading Factor (*SF*)
  - Coding Rate (*CR*)
  - Transmission Power (*Tx*)

- Metrics
  - Receiver Sensitivity (*RS*)
  - Signal Noise Rate (*SNR*)
  - Data Rate (*DR*)
  - Air Time (*AT*)
  - Payload length (*PktL*)

Setting	Values	Rewards	Costs
BW	7.8 ➠ 500*kHz*	*DR*	*RS*, Range
SF	2^6 ➠ 2^{12}	*RS*, Range	*DR*, *SNR*, *PktL*, *Tx*
CR	4/5 ➠ 4/8	Resilience	*PktL*, *Tx*, *AT*
Tx	−4 ➠ 20*dBm*	*SNR*	*Tx*

Table 1. [1]

[1] M. Cattani, C. Boano, and K. Römer, " An Experimental Evaluation of the Reliability of Lora Long-Range Low-Power Wireless Communication ", *Journal of Sensor and Actuator Networks*, vol. 6, no. 2, p. 7, 2017, 00042.

[2] **dimartino_internet_2018**.

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Multi-Armed-Bandit Algorithm

Related work

- Arms: K = 1, ... , K
- Decision: T = 1, ... , T
- Reward: X_t^k with μ_t^k = E $[X_t^k]$
  - Best reward: X_t^* with μ_t^* = max μ_t^k, k∈K

Outline

Genetic Algorithm

Related work **alkhawlani_access_2008a**

- Heterogeneous wireless network: (RAT 1 ,RAT 2 ,...,RAT n)
- Criteria up to i (c 1 ,c 2 ,...,c i) the operators, the applications, and the network conditions.
-
- The different sets of scores (d 1 , d 2 ,...,d i) are sent to the MCDM in the second component.
- GA component assigns a suitable weight (w 1 ,w 2 ,...,w i)

Genetic Algorithm

Related work

-
- S = SF12, BW125, 4/8, 17 dBm
- Input:
  - Problem: f(x) = max(x^2), x ∈[0,32]
    - $x_1 : 01101_b$
    - $x_2 : 11000_b$
    - $x_3 : 01000_b$
    - $x_4 : 10011_b$
- Method: Genetic algorithm
  - Generate a set of random possible solution
  - Test each solution and see how good it is (ranking)
    - Remove some bad solutions
    - Duplicate some good solutions
    - Make small changes to some of them (Crossover, Mutation)
- Output:
  - x_1: 01101 (169) (14.4)
  - x_2: 11000 (576) (49.2)
  - x_3: 01000 (64) (5.5)
  - x_4: 10011 (361) (30.9)

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Marcov chain

Related work

$$V(s,\pi) = \mathbb{E}_s^\pi\left(\sum_{k=0}^{\inf} \gamma^k \cdot r(s_k, a_k)\right), s \in \mathbb{S} \tag{1}$$

$$r(s_k, a_k) = G_k \cdot PRR(a_k) \tag{2}$$

$$\pi^* = \arg\max_\pi V(s,\pi) \tag{3}$$

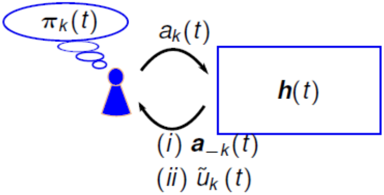
$$PRR = (1 - BER)^L \tag{4}$$

$$BER = 10^{\alpha e^{\beta SNR}} \tag{5}$$

Marcov chain
Related work

Learning Iterative Steps:

- **Choose** action $a_k(t) \sim \pi_k(t)$.
- **Observe** game outcome, e.g.,
  $\boldsymbol{a}_{-k}(t)$
  $u_k(a_k(t), \boldsymbol{a}_{-k}(t))$.
- **Improve** $\pi_k(t+1)$.



Thus, we can expect that: $\forall k \in \mathcal{K}$,

$$\pi_k(t) \xrightarrow{t\to\infty} \pi_k^* \quad (1)$$

$$\bar{u}_k\left(\pi_k(t), \pi_{-k}(t)\right) \xrightarrow{t\to\infty} \bar{u}_k\left(\pi_k^*, \pi_{-k}^*\right) \quad (2)$$

where, $\pi^* = (\pi_1^*, \ldots, \pi_K^*)$ is a NE strategy profile.

Figure 1. .

Outline

1. Genetic Algorithm For LoRa Transmission Parameter Selection

1. Problem statement
2. Related work
3. Background
4. Method
5. Experimentation
6. Results
7. Discussion

1. Bandit Algorithm
2. Genetic Algorithm
3. Marcov chain
4. Game theory

Game theory

Related work

- Players: $K = \{1, ..., K\}$
- Strategies: $S = S_1 \times \ldots \times S_K$
  - S_k is the strategy set of the k^{th} player.
- Rewards: $u_k : S \longrightarrow R_+$ and is denoted by $r_k(s_k, s_{-k})$
  - $s_{-k} = (s_1, \ldots, s_{k-1}, s_{k+1}, \ldots, s_K) \in S_1 \times \ldots \times S_{k-1} \times S_{k+1} \times \ldots \times S_K$

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... (step 2)

Methods

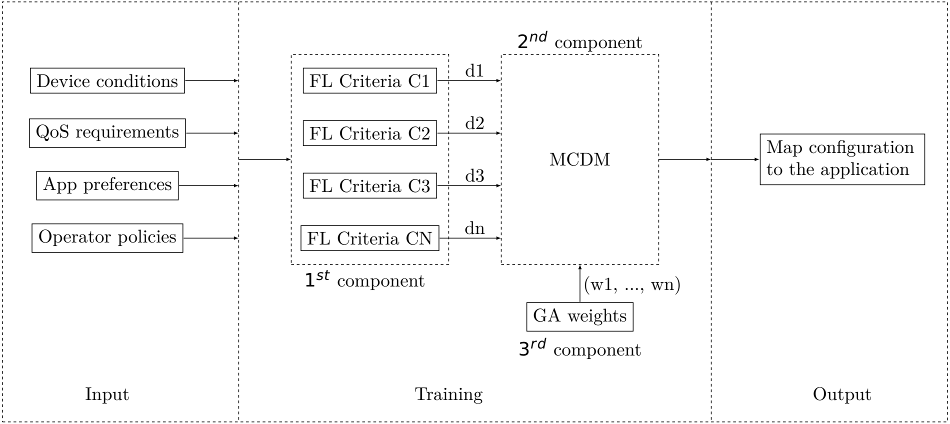

Figure 2. HH.

... (step 3)

Methods

... (step 4)

Methods

Outline

1. Genetic Algorithm For LoRa Transmission Parameter Selection

Contribution

Contributions

- **Use cases (Application Requirements)**
  - Smart building: Voice, Images, Text.
- **Environments**
  - Rural/Urban
  - Static/Mobile
  - Temperature
- **Scenarios**
  - Application protocol (MQTT, COAP, XMPP)
  - Network protocol (Start, Mesh)
  - MAC protocol (LoraWan, Sigfox, ...)
- **Input:**
  - Service QoS metrics requirements
  - MAC configuration (SF, CR, BW, ...)
  - Network QoS metrics
- **Algorithms:**
  - MADM
    - Ranking methods
    - Ranking & weighted methods
  - Game theory
    - Users vs users
    - Users vs networks
    - Networks vs network
  - Fuzzy logic
    - as a score method
    - another theory
  - Utility function
    - 1
    - 2
- **Outputs:**
  - Ranked networks

Technical choice

Implementation

- ZOLERTIA RE-MOTE
  - Low consumption component
  - ADC port for placing sensors on it
- CONTIKI OS
  - Operating system for wireless and low power development
  - Support for newer standards (6LowPAN, RPL, CoAP, MQTT)
- 6LowPAN
  - Based on IPv6 and IEEE 802.15.4
  - IPv6-based network with low power consumption
  - Ability to create a mesh network
- Sending packages
  - UDP in the 6LowPAN network
  - MQTT between the cloud platform and the router

Experimentation

Experimentation

- a
- b

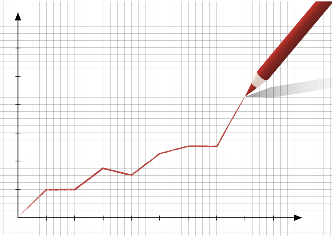

Figure 3. .

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Results

Comparison

- a
- b

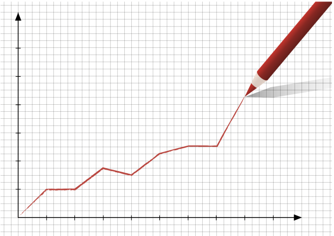

Figure 4. .

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Discussion

- a
- b

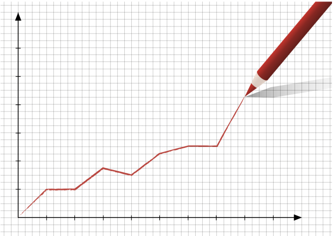

Figure 5. .

References

[1] M. Cattani, C. Boano, and K. Römer, "An Experimental Evaluation of the Reliability of Lora Long-Range Low-Power Wireless Communication", *Journal of Sensor and Actuator Networks*, vol. 6, no. 2, p. 7, 2017, 00042.