

# IoT challenges

State of the art

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# Outline

1. Introduction

2. First contribution

3. Conclusion

# Context

What is IoT ?

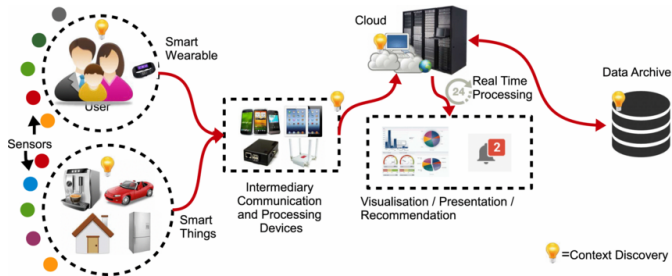


Figure 1: IoT platform.



Figure 2: IoT challenges.

# Problematic

Where is the problem ?

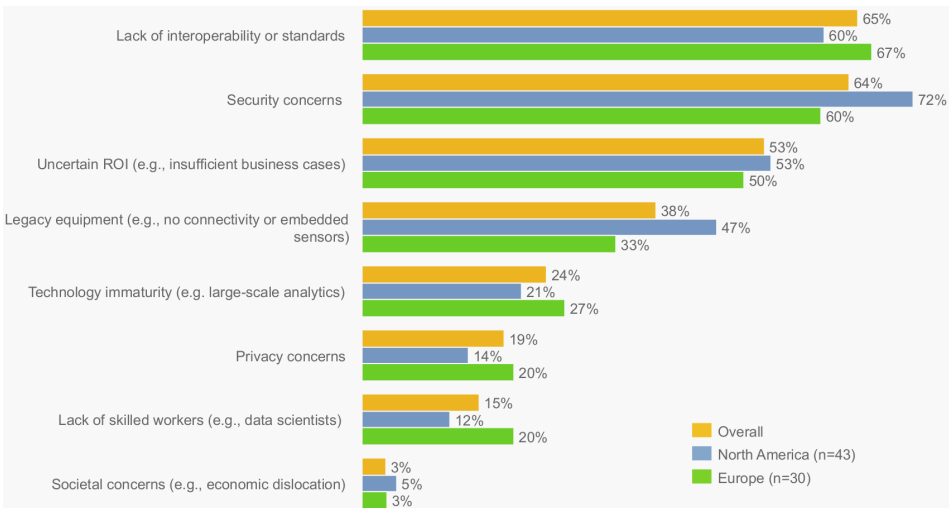


Figure 3: Key barriers in adopting the Industrial Internet [industrialinternetofthings\_executive\_].

# Problematic

Where is the problem ?

- ➡ Some network configuration are static and not adptive to the application
  - ➡ Decision and optimisation problem..
  - ➡ Various network acces
  - ➡ Various configuration of each network acces
  - ➡ Lake of selection tools
- ➡ Users have to select the network and the application
  - ➡ How to select the **best** network.
  - ➡ How to select the network required by the application.

# Context

## Introduction

### IoT Applications

- Health care
- Transportation**
- Industry
- Market
- School
- Vehicles
- Smart Home
- Agriculture



Figure ??: IoT Applications

# Problematic

Where is the problem [2] ?

Bandwidth (*BW*) Spreading Factor (*SF*) Coding Rate (*CR*) Transmission Energy (*Tx*) Receiver Sensitivity (*RS*) Signal Noise Rate (*SNR*) Data Rate (*DR*) ,Air Time (*AT*)

Setting	Values	Rewards	Cost
<i>BW</i>	7.8 $\Rightarrow$ 500kHz	<i>DR</i>	<i>RS</i> , Range.
<i>SF</i>	$2^6 \Rightarrow 2^{12}$	<i>RS</i> , Range	<i>DR</i> , <i>SNR</i> , longer packets, <i>Tx</i> .
<i>CR</i>	4/5 $\Rightarrow$ 4/8	Resilience	longer packets, <i>Tx</i> , <i>AT</i> .
<i>Tx</i>	-4 $\Rightarrow$ 20dBm	<i>SNR</i>	<i>Tx</i>

Table 1: [1]

# 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





# Motivations

Who & why cares with such problems ?

- a
- Lake of selective tools
- How to select the **best** access point

## QoS Analysis

- a
- Lake of selective tools
- How to select the **best** access point

## Threats

- a
- Lake of selective tools
- How to select the **best** access point

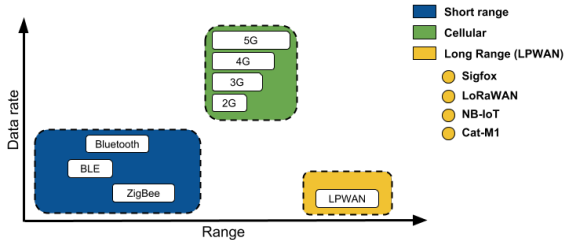


Figure 4: Communication diversity.

# Goal

What is the goal ?

- ➡ ➡ Allow heterogeneous network to communicate
- ➡ ➡ QoS Analysis
- ➡ ➡ Threats
- ➡ ➡ How to select the **best** access point
  - ➡ ➡ Allow heterogeneous network to communicate
  - ➡ ➡ QoS Analysis
  - ➡ ➡ Threats



Figure 5: wsn-IoT.

# Goal

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- ➡ ➡ QoS Analysis
- ➡ ➡ Threats
- ➡ ➡ How to select the **best** access point
  - ➡ ➡ Allow heterogeneous network to communicate
  - ➡ ➡ QoS Analysis
  - ➡ ➡ Threats



Figure 5: wsn-IoT.

# Map the network to service requirement ?

# Challenges

Where is the difficulty ?

- ➡ Reasonable and acceptable delay before the decision appears.
- ➡ Cope with the different view points and goals of the operators and the users.
- ➡ React to the changing environment conditions.
- ➡ Allow any type of inputs and to be applicable to any type of ANs.
- ➡ Handle the increasing number of RATs and the large number of criteria.

# Contributions

## Contributions

- ➡ Use cases (Requirements)
  - ➡ Smart building: Videos, Voice, Text.
  - ➡ Smart traffic: Videos, Voice, Text
- ➡ Environnements
  - ➡ Rural/Urban
  - ➡ Static/Mobile
  - ➡ Temperature
- ➡ Senarios
  - ➡ For each application protocol (MQTT, COAP, XMPP)
  - ➡ For each network protocol (Start, Mesh)
  - ➡ For each MAC protocol (LoraWan, Sigfox, ...)
- ➡ Algorithms
  - ➡ Input:
    - \* Service QoS metrics requiremnts
    - \* MAC configuration (SF, CR, BW, ...)
    - \* Network QoS metrics
  - ➡ Method:
    - \* MADM, Game, Neural
  - ➡ Outputs:
    - \* Ranked networks

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Theoretical, Simulation & Real environnement

# Outline

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2. First contribution

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1. Introduction

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1. Related work

2. Contagion process

3. Experimentation

4. Results exploitation

5. Discussion

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# Related work

## Comparison

Paper	A1	A2	A3	A4

Table 2: An example table.

# Related work

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Paper	A1	A2	A3	A4

Table 3: An example table.

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# Multi-Armed-Bandit Algorithm

## Methods

- ⇒ Arms:  $K = 1, \dots, K$
- ⇒ Decision:  $T = 1, \dots, T$
- ⇒ Reward:  $X_t^k$  with  $\mu_t^k = E[X_t^k]$ 
  - ⇒ Best reward:  $X_t^*$  with  $\mu_t^* = \max_{k \in K} \mu_t^k$

# Genetic Algorithm

Methods [alkhawlani\_access\_2008a]

- ➡ Heterogeneous wireless network: (RAT 1 ,RAT 2 ,...,RAT n)
- ➡ Criteria up to  $i$  ( $c_1, c_2, \dots, c_i$ ) the operators, the applications, and the network conditions.
- ➡
- ➡ The different sets of scores ( $d_1, d_2, \dots, d_i$ ) are sent to the MCDM in the second component.
- ➡ GA component assigns a suitable weight ( $w_1, w_2, \dots, w_i$ )

# Marcov chain

## Methods

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

$$r(s_k, a_k) = G_k \cdot PRR(a_k) \quad (2)$$

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

$$PRR = (1 - BER)^L \quad (4)$$

$$BER = 10^\alpha e^{\beta SNR} \quad (5)$$





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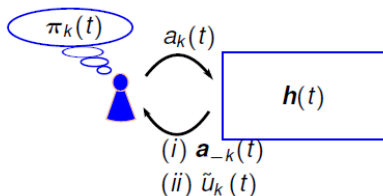
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$$PRR = (1 - BER)^L \quad (4)$$

$$BER = 10^{\alpha} e^{\beta SNR} \quad (5)$$

## Learning Iterative Steps:

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



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

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

$$\bar{U}_k(\pi_k(t), \pi_{-k}(t)) \xrightarrow{t \rightarrow \infty} \bar{U}_k(\pi_k^*, \pi_{-k}^*) \quad (2)$$

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

Figure 6: .

# Genetic Algorithm

## Methods



➡ S = SF12, BW125, 4/8, 17 dBm



Input:

➡ Problem:  $f(x) = \max(x^2)$ ,  $x \in [0,32]$

\*  $x_1 : 01101_b$

\*  $x_2 : 11000_b$

\*  $x_3 : 01000_b$

\*  $x_4 : 10011_b$



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)

# Game theory

## Methods

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

## ... (step 2)

Methods



## ... (step 3)

Methods



## ... (step 4)

Methods



# Results

## Comparison


Table 4



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# Experimentation

## Experimentation

➡ a

➡ b

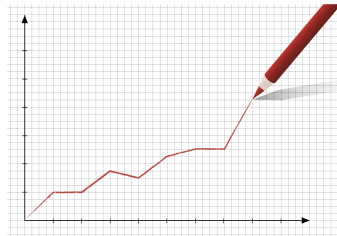


Figure 7: .

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# Results

## Comparison

➡ a

➡ b

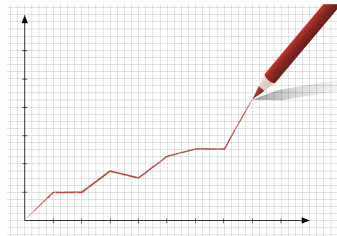


Figure 8: .

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# Discussion

➡ a

➡ b

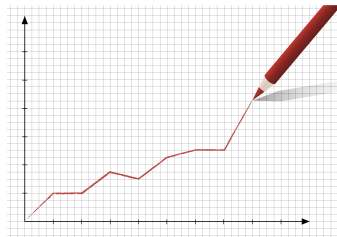


Figure 9: .

# Outline

1. Introduction
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# Conclusion

Our main goal was



Our main contribution was



Our main results was





# Future Challenges

## Conclusion

Our future goal was



# Future Challenges

## Conclusion

Our future goal was



# Thank you !

# References

- [1] Marco Cattani, Carlo Boano, and Kay Römer. " An Experimental Evaluation of the Reliability of Lora Long-Range Low-Power Wireless Communication ". In: *Journal of Sensor and Actuator Networks* 6.2 (2017). 00042, p. 7 (p. 7).
- [2] B. Di Martino et al. " Internet of Things Reference Architectures, Security and Interoperability: A Survey ". In: *Internet of Things* 1-2 (Sept. 2018). 00006, pp. 99–112 (p. 7).