Valorisation de publication

Pourquoi faire une these ?

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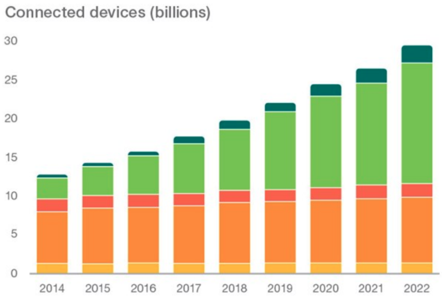
Why I started a PhD ?

3 main reasons

- Research methodology lecture.
- Bac+5 in networking ? not really !
- Being paid to study and develop yourself !

IoT devices

IoT devices are useless without a good communication capability



	2016	2022	CAGR
Wide-area IoT	0.4	2.1	30%
Short-range IoT	5.2	16	20%
PC/laptop/tablet	1.6	1.7	0%
Mobile phones	7.3	8.6	3%
Fixed phones	1.4	1.3	0%
	16 billion	29 billion	10%

Figure 1: IoT devices [1].

IoT applications requirements

Each application has its own communication requirements

Challenges/Applications	Grids	EHealth	Transport	Cities	**Building**
Resources constraints	✗	✓	✗	-	✗
Mobility	✗	-	✓	✓	✗
Heterogeneity	-	-	-	✓	✗
Scalability	✓	-	✓	✓	-
QoS constraints	-	-	✓	✓	✓
Data management	-	✗	✓	✓	-
Lack of Standardization	-	-	-	-	✓
Amount of attacks	✗	✗	✓	✓	✓
Safety	-	✓	✓	-	✓

Table 1: Main IoT challenges [2] [3]

Figure 2: IoT Applications.

IoT platforms

IoT platforms is a chain of communication process

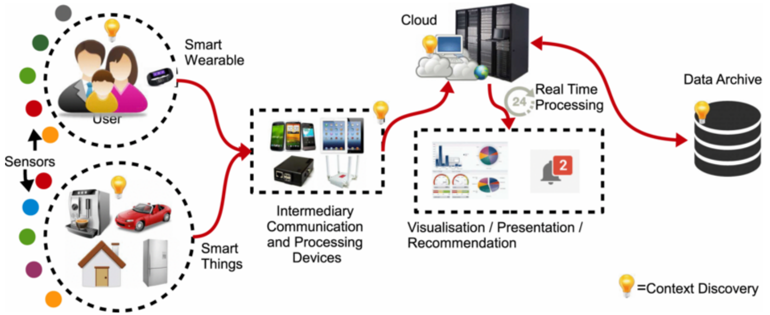


Figure 3: IoT platform.

Figure 4: IoT challenges.

IoT applications requirements

Context

Use Case	Packet rate [pkt/day]	Min success rate [Ps,min]	Payload Size [Byte]
Wearables	10	90	
Smoke Detectors	2	90	
Smart Grid	10	90	10-20
White Goods	3	90	
Waste Management	24	90	
VIP/Pet Tracking	48	90	
Smart Bicycle	192	90	
Animal Tracking	100	90	
Environmental Monitoring	5	90	
Asset Tracking	100	90	50
Smart Parking	60	90	
Alarms/Actuators	5	90	
Home Automation	5	90	
Machinery Control	100	90	
Water/Gas Metering	8	90	
Environmental Data Collection	24	90	
Medical Assisted Living	8	90	
Micro-generation	2	90	
Safety Monitoring	2	90	100-200
Propane Tank Monitoring	2	90	
Stationary Monitoring	4	90	
Urban Lighting	5	90	
Vending Machines Payment	100	90	
Vending Machines General	1	90	1K

Table 2: Application requirements for the use cases of interest [4] [3].

IoT wireless communication

Wireless communication performance need to be evaluated to match applications requirements

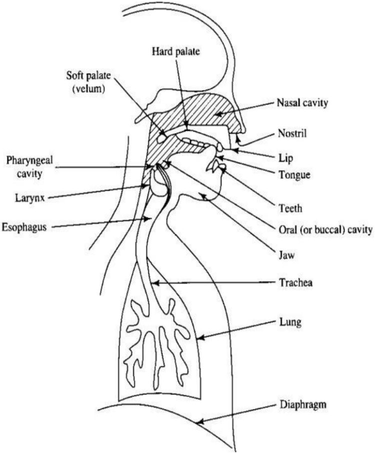


Figure 5: Human voice.

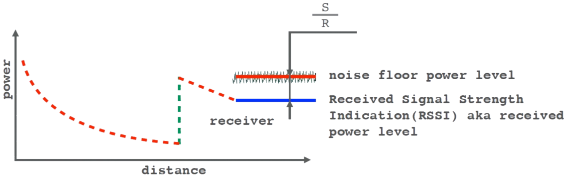


Figure 6: SNR & RSSI.

Figure 7: Time on air.

IoT wireless communication

Exp: LPWAN in a new technology that satisfy IoT applications requirements

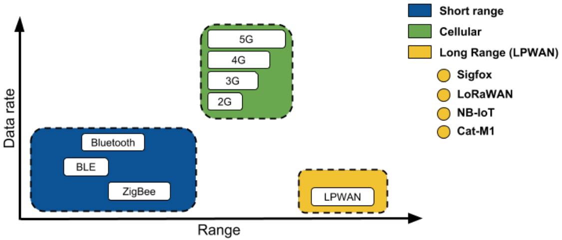


Figure 8: Wireless communication diversity.

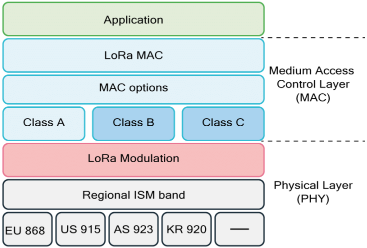


Figure 9: LoRa and LoraWan stack.

Problematic

Network configuration is the problem number one actually

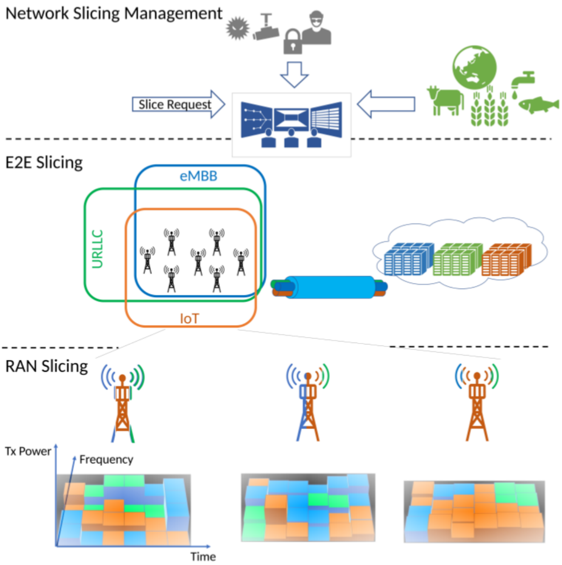


Figure 10: Key barriers in adopting IoT in the industry [5].

Problematic

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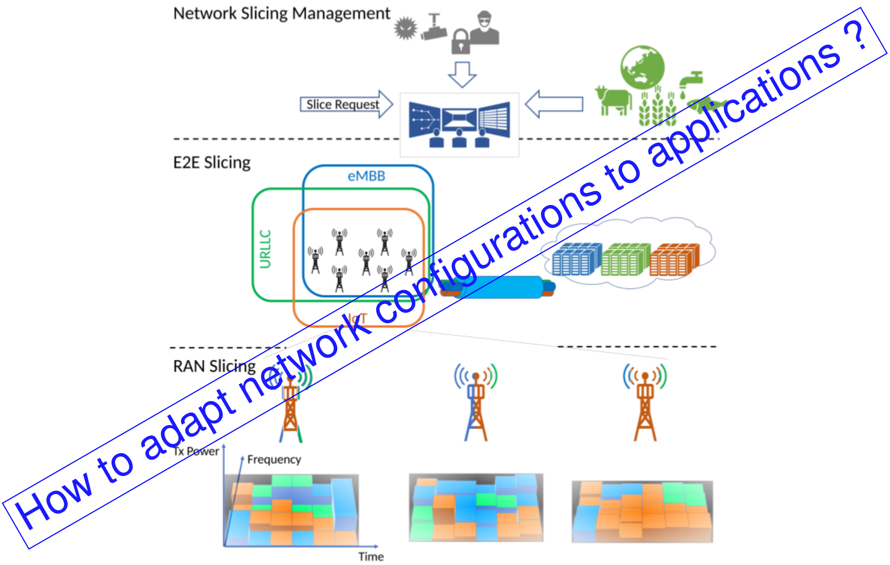


Figure 10: Key barriers in adopting IoT in the industry [5].

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.

Network slicing

Exp: 4G/5G, Content provider (GAFA) want to be directly connected to users devices

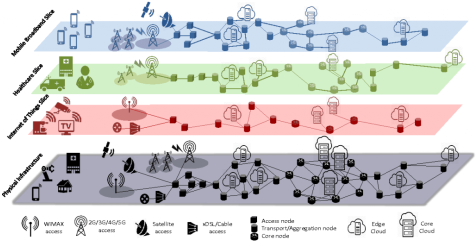
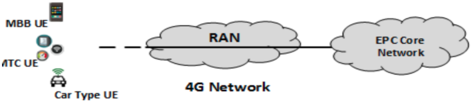
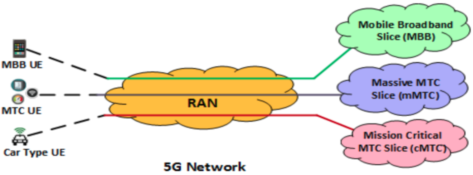


Figure 11: Network slicing [5].



(a) 4G without network slicing.



(b) 5G with network slicing.

Figure 12: Network slicing concept [6].

Conclusion

In the future, network administration function will disappear and will be replaced by a slice orchestrator

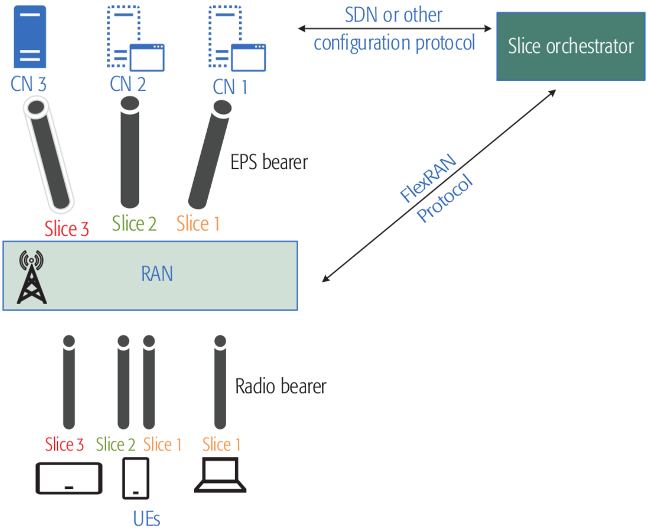


Figure 13: Slice orchestrator [7].

Conclusion

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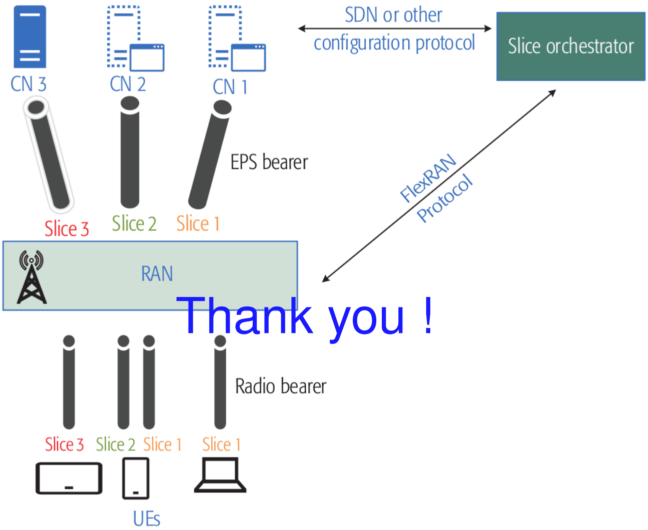

Thank you !

Figure 13: Slice orchestrator [7].

Challenges

Where is the difficulty ?

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

Outline

1. Genetic Algorithm For LoRa
    1. Problem statement
    2. Related work
    3. Background
    4. Method
    5. Experimentation

Outline

1. Genetic Algorithm For LoRa

1. Problem statement
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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 ➠ 500kHz	*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 ➠ 20dBm	*SNR*	*Tx*

Table 3: [1]

[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.

[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.

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

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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

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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)

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Marcov chain

Related work

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

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

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

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

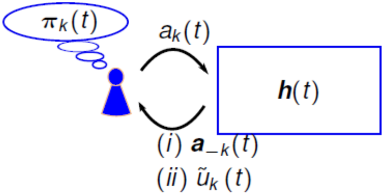
$$BER = 10^{\alpha e^{\beta SNR}} \tag{5}$$

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: $\forall k \in \mathcal{K}$,

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

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

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

Figure 14: .

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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

-
-

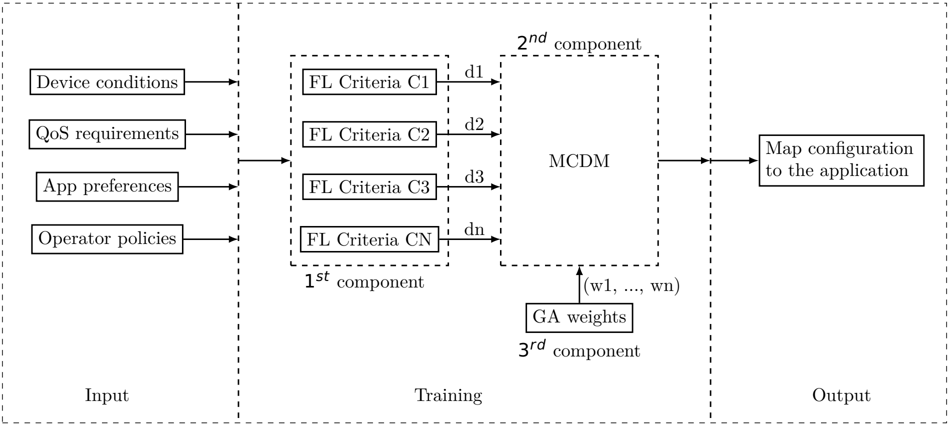

Figure 15: HH.

... (step 3)

Methods

... (step 4)

Methods

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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

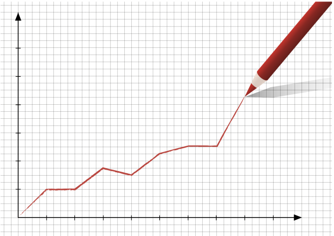

Figure 16: .

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