

# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. x-Long paper
6. Genetic Algorithm For LoRa
7. EES
8. Template
9. UTLC
10. Conclusion

# Why I started a PhD ?

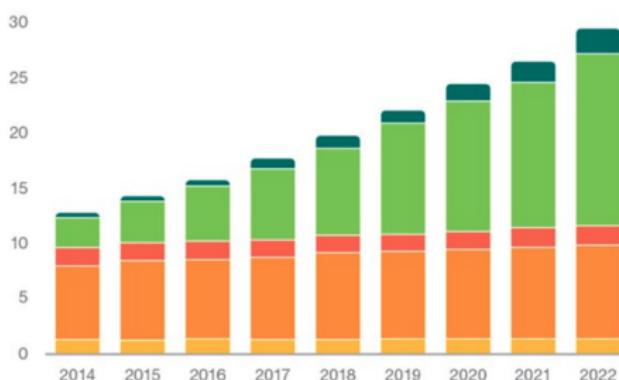
3 main reasons

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

# IoT devices

IoT devices are useless without a good communication capability

Connected devices (billions)



	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	✗	-	✓	✓	✗
<b>Heterogeneity</b>	-	-	-	✓	✗
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

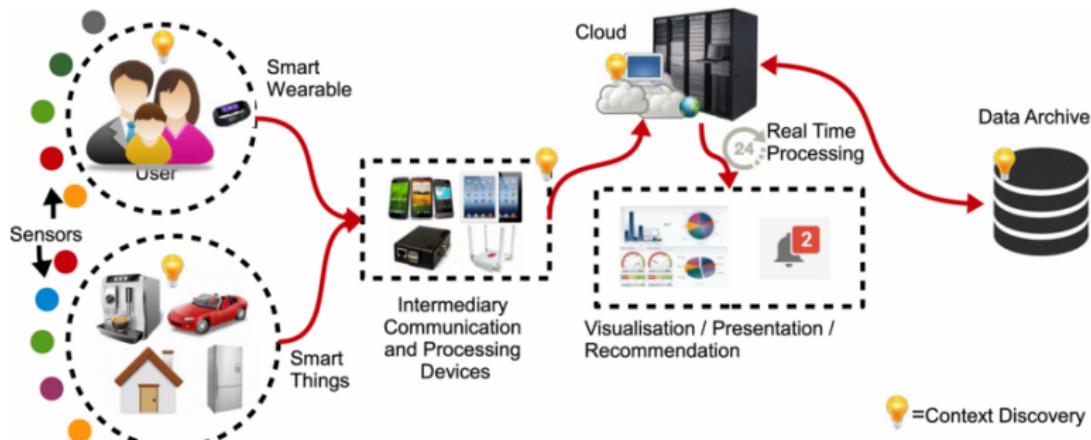


Figure 3. IoT platform.



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

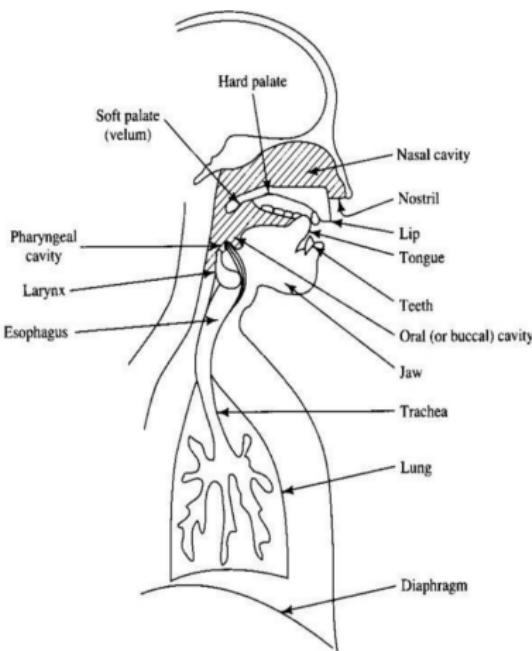


Figure 5. Human voice.

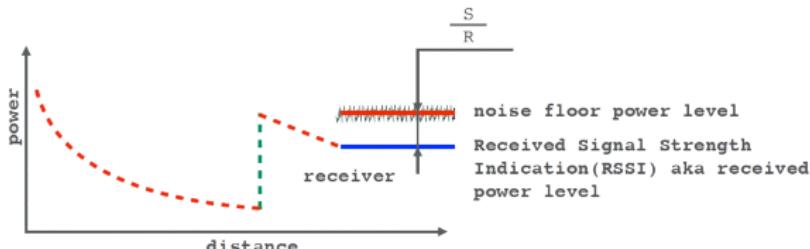


Figure 6. SNR & RSSI.



Figure 7. Time on air.

# Problem statement

Introduction<sup>2</sup> ?

- ➡ 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
<i>BW</i>	7.8 ➡ 500kHz	<i>DR</i>	<i>RS, Range</i>
<i>SF</i>	$2^6 \Rightarrow 2^{12}$	<i>RS, Range</i>	<i>DR, SNR, PktL, Tx</i>
<i>CR</i>	4/5 ➡ 4/8	Resilience	<i>PktL, Tx, AT</i>
<i>Tx</i>	-4 ➡ 20dBm	<i>SNR</i>	<i>Tx</i>

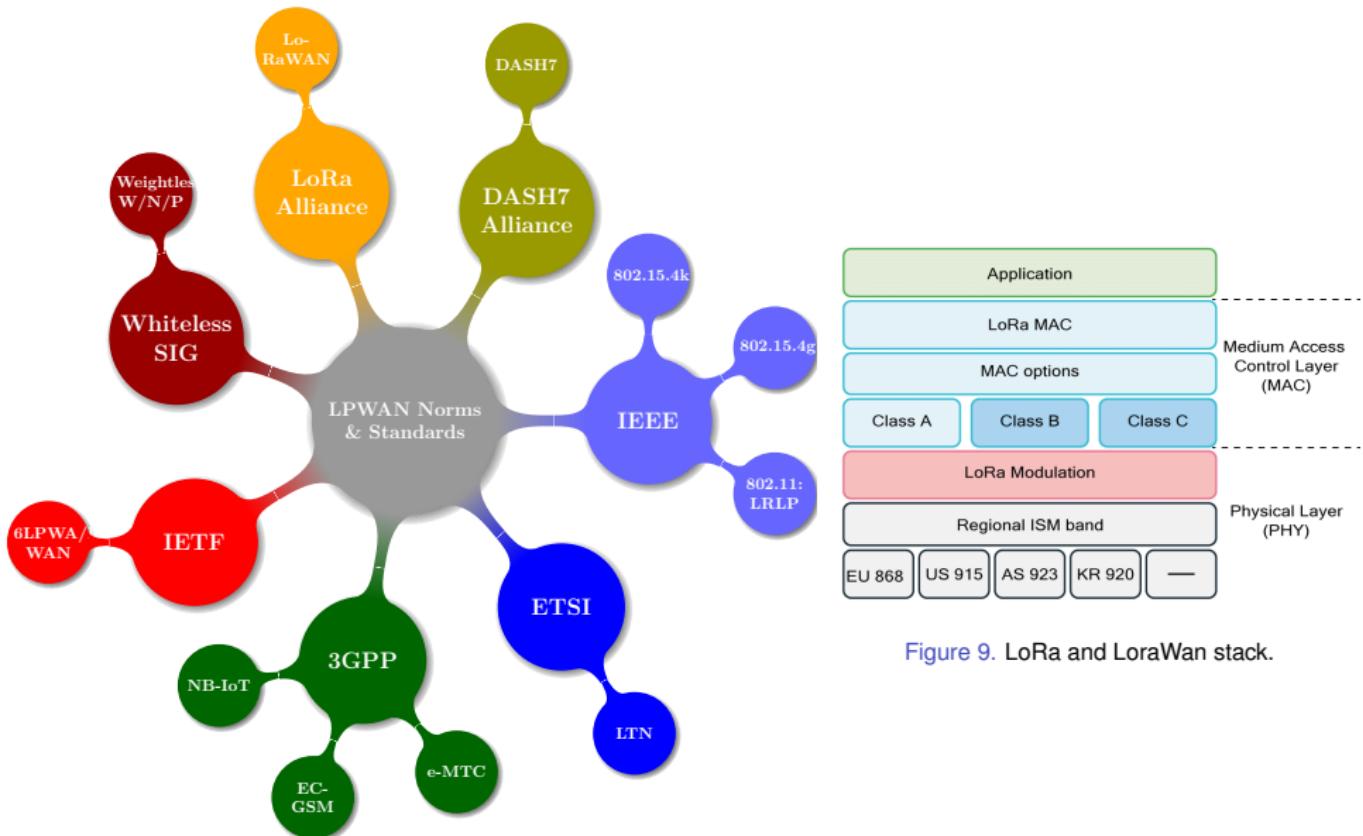
Table 3. <sup>1</sup>

<sup>1</sup>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.

<sup>2</sup>dimartino\_internet\_2018.

# IoT wireless communication

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



# Problematic

One size fits all problem: 1) Many configurations, 2) Diversity of service requirements

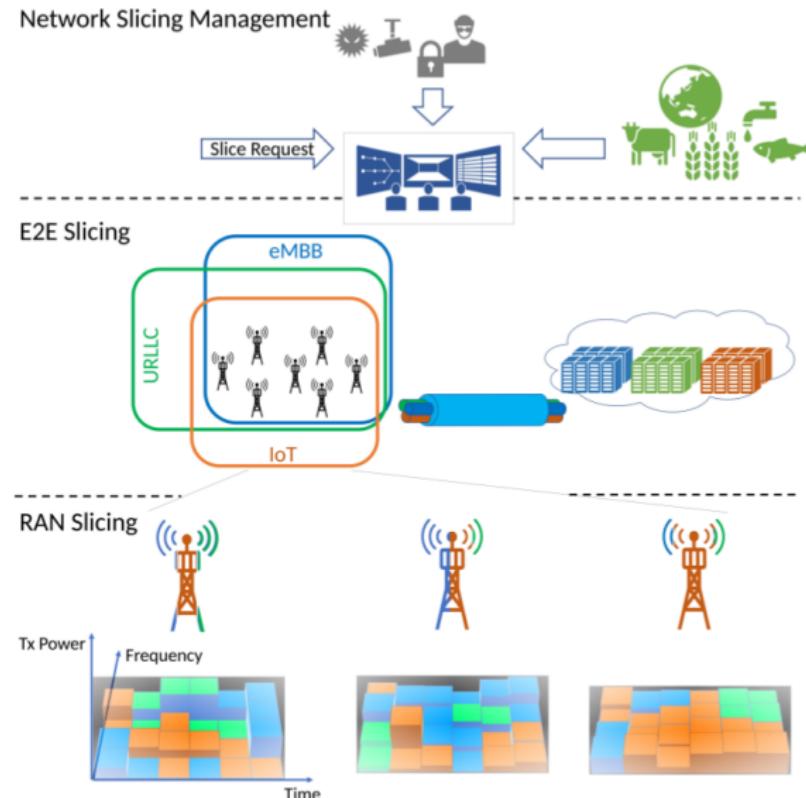


Figure 10. Key barriers in adopting IoT in the industry [6].

# Problematic

One size fits all problem: 1) Many configurations, 2) Diversity of service requirements

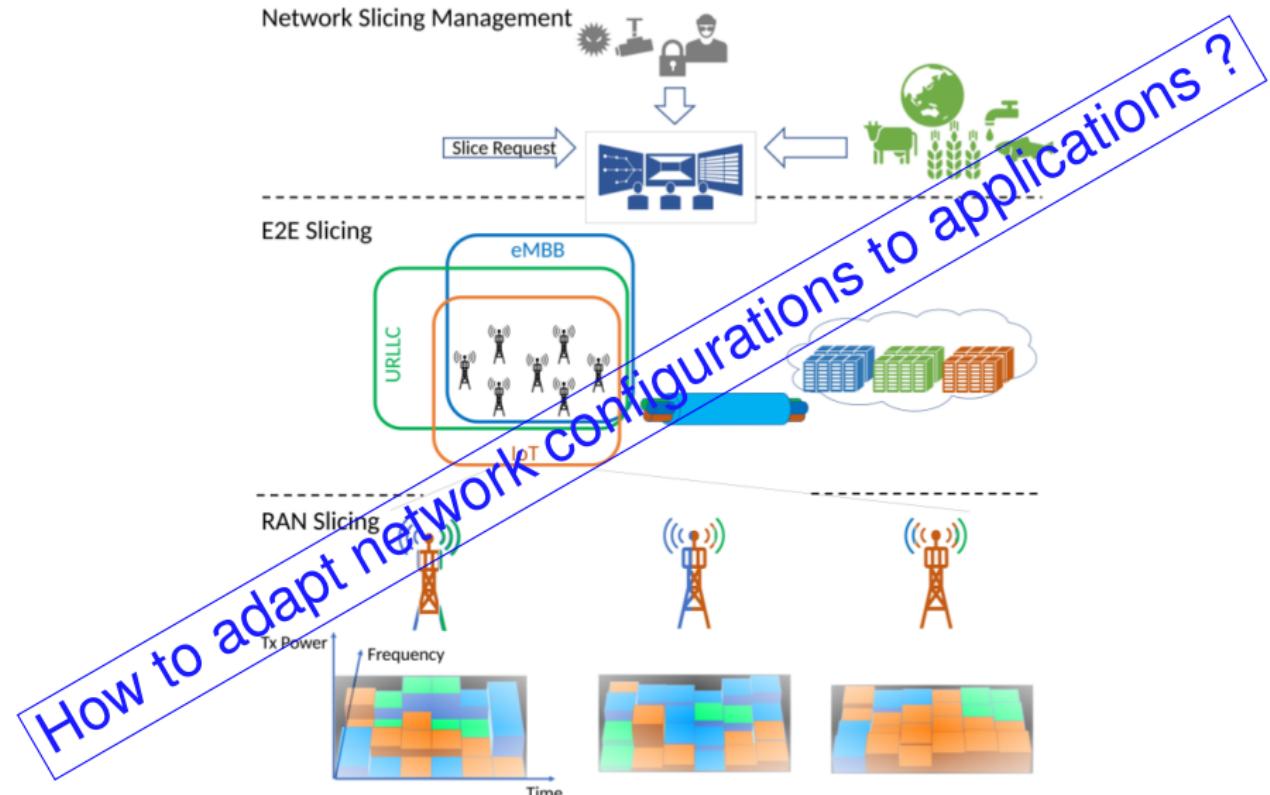


Figure 10. Key barriers in adopting IoT in the industry [6].

# Problematic

Where is the problem ?

- ➡ Some network configuration are static and not adaptive to the application
  - Decision and optimisation problem..
  - Various network access
  - Various configuration of each network access
  - Lack 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.

# End-to-end Network slicing

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

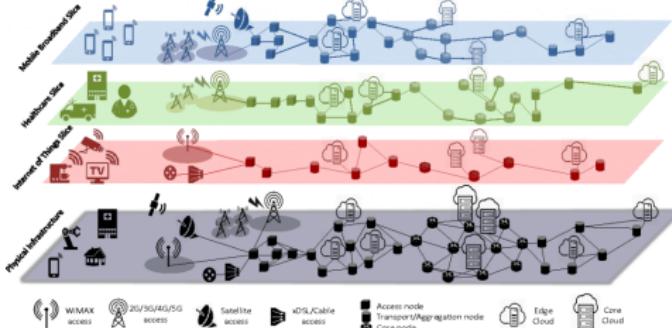


Figure 11. Network slicing [6].

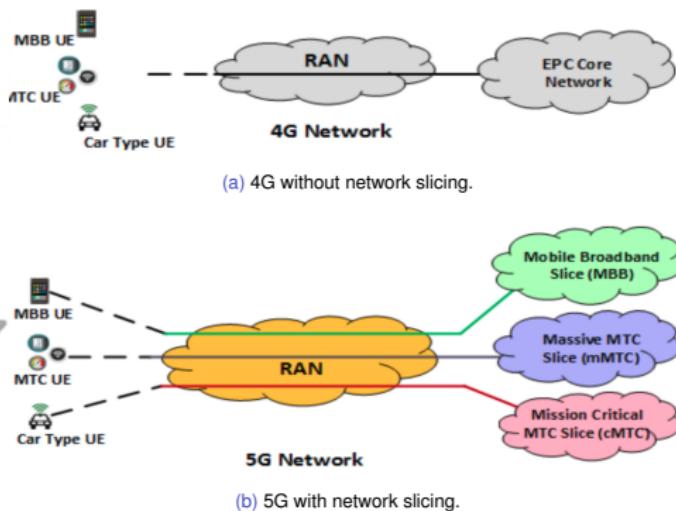


Figure 12. Network slicing concept sama\_servicebased\_2016.

# Conclusion

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

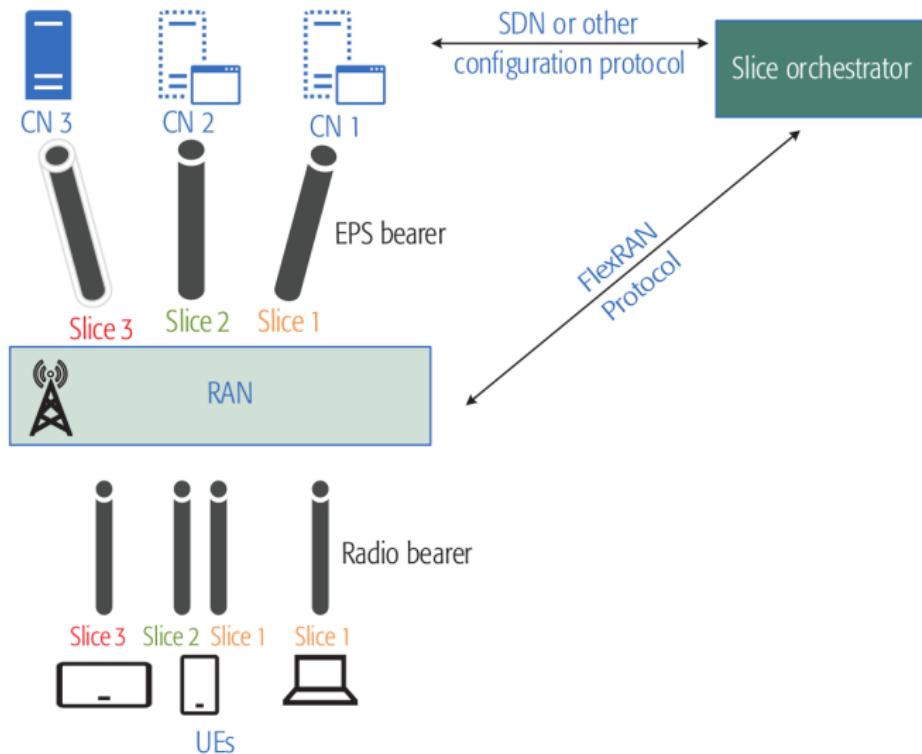


Figure 13. Slice orchestrator [7].

# Conclusion

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

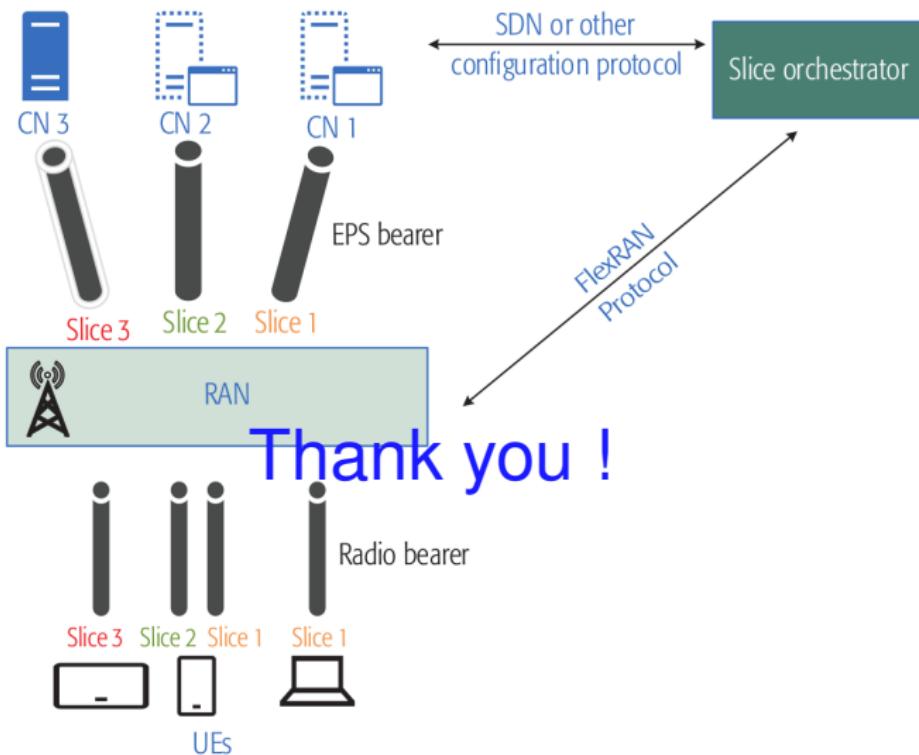


Figure 13. Slice orchestrator [7].

# Contribution

## Contributions

- **3 Applications**

- Voice, Images and Text transmission.

- **3 Environment conditions**

- Rural/Urban
  - Static/Mobile
  - Temperature

- **6 Scenarios**

- Application protocol (MQTT, COAP, XMPP)
  - Network protocol (Star, Mesh)
  - MAC protocol (LoraWan, Sigfox, ...)

- **6 algorithms**

- ..
  - ..
  - ..

- **Inputs:**

- QoS metrics:
    - ★ User metrics: Cost
    - ★ Network metrics: Receiver sensitivity, SNR, DR, Air time, Payload length.

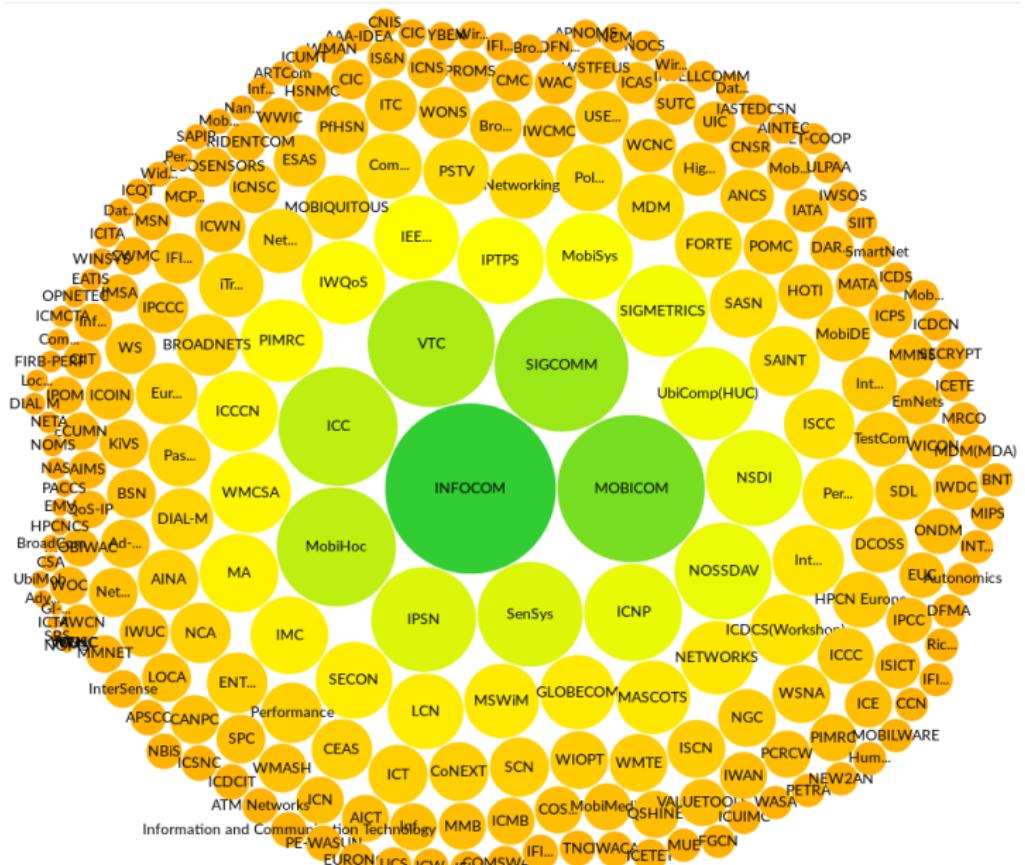
- MAC configuration (SF, CR, BW, Tx)

- **Outputs:**

- $(SF_i, CR_j, BW_k, Tx_l)$

## Contribution

## Contributions



# Outline

1. Introduction

2. State of the art

3. x-Testbed

4. x-Sentilo

5. x-Long paper

6. Genetic Algorithm For LoRa

7. EES

8. Template

9. UTLC

10. Conclusion

- 1. MADM
- 2. Learning
- 3. Fuzzy Logic
- 4. Utility Function
- 5. Game Theory
- 6. Discussion

# Outline

1. Introduction

2. State of the art

3. x-Testbed

4. x-Sentilo

5. x-Long paper

6. Genetic Algorithm For LoRa

7. EES

8. Template

9. UTLC

10. Conclusion

## 1. MADM

2. Learning

3. Fuzzy Logic

4. Utility Function

5. Game Theory

6. Discussion

# Outline

1. Introduction

2. State of the art

3. x-Testbed

4. x-Sentilo

5. x-Long paper

6. Genetic Algorithm For LoRa

7. EES

8. Template

9. UTLC

10. Conclusion

1. MADM

2. Learning

3. Fuzzy Logic

4. Utility Function

5. Game Theory

6. Discussion

1. Bandit Algorithm

2. Genetic Algorithm

3. Q-Learning

4. Marcov Chain

# Outline

1. Introduction

2. State of the art

3. x-Testbed

4. x-Sentilo

5. x-Long paper

6. Genetic Algorithm For LoRa

7. EES

8. Template

9. UTLC

10. Conclusion

1. MADM

2. Learning

3. Fuzzy Logic

4. Utility Function

5. Game Theory

6. Discussion

1. Bandit Algorithm

2. Genetic Algorithm

3. Q-Learning

4. Marcov Chain

# Multi-Armed-Bandit Algorithm

## Related work

- ➡ 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  $\mu_t^* = \max \mu_t^k, k \in K$

# Outline

1. Introduction

2. State of the art

3. x-Testbed

4. x-Sentilo

5. x-Long paper

6. Genetic Algorithm For LoRa

7. EES

8. Template

9. UTLC

10. Conclusion

1. MADM

2. Learning

3. Fuzzy Logic

4. Utility Function

5. Game Theory

6. Discussion

1. Bandit Algorithm

2. Genetic Algorithm

3. Q-Learning

4. Marcov Chain

# Genetic Algorithm

Related work [alkhawlani\\_access\\_2008a](#)

- ➡ **N** transceiver configurations:  $(x_1, \dots, x_n)$
- ➡ **I** QoS metrics  $(m_1, \dots, m_i)$ . ex: the operators, the applications, and the network conditions.
- ➡ **I** weights  $(w_1, \dots, w_i)$  are sent to the MCDM in the second component.
- ➡ GA component assigns a suitable weight  $(w_1, w_2, \dots, w_i)$

# Genetic Algorithm

Related work

## Evaluation function

Define the number of parameters

{SF, Tx, CR, BW}

Define the target QoS

{RSSI, SNR, delay, PDR, RTD}

Define evaluation function

**Score**(SF, Tx, CR, BW) -> {RSSI, SNR, delay, PDR, RTD}

## Parameters

Define a population of individuals (solutions)

6720

Define probabilities of crossing and mutating

0.5, 0.2

Define the number of generations

60

## Generations

Select individuals randomly

$\{SF_i, Tx_i, CR_i, BW_i\}^{random}$

Clone, crossover and mutate this individuals

$\{SF_{i+1}, Tx_{i+1}, CR_{i+1}, BW_{i+1}\}^{random}$

Evaluate the offspring with an invalid Fitness

**Score**( $SF_{i+1}, Tx_{i+1}, CR_{i+1}, BW_{i+1}$ )

## (Crossover, Mutation)

Remove some bad solutions

Duplicate some good solutions

Make small changes to some of them

# Outline

1. Introduction

2. State of the art

3. x-Testbed

4. x-Sentilo

5. x-Long paper

6. Genetic Algorithm For LoRa

7. EES

8. Template

9. UTLC

10. Conclusion

1. MADM

2. Learning

3. Fuzzy Logic

4. Utility Function

5. Game Theory

6. Discussion

1. Bandit Algorithm

2. Genetic Algorithm

3. Q-Learning

4. Marcov Chain

# Marcov chain

## Related work

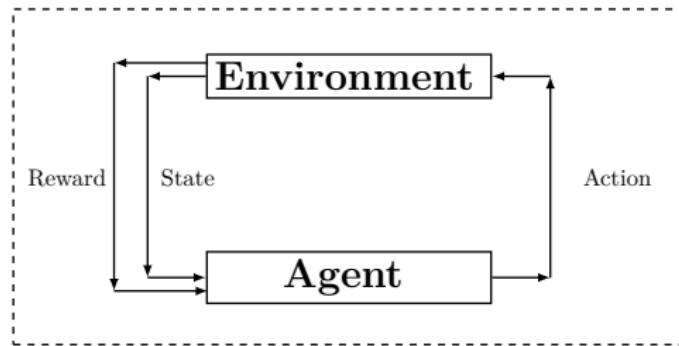


Figure 15. qlearning.

# Outline

1. Introduction

2. State of the art

3. x-Testbed

4. x-Sentilo

5. x-Long paper

6. Genetic Algorithm For LoRa

7. EES

8. Template

9. UTLC

10. Conclusion

1. MADM

2. Learning

3. Fuzzy Logic

4. Utility Function

5. Game Theory

6. Discussion

1. Bandit Algorithm

2. Genetic Algorithm

3. Q-Learning

4. Marcov Chain

# Marcov chain

## Related work

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

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

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

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

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

# Marcov chain

## Related work

Learning iterative steps:

- ➡ **Choose** action  $a_k(t) \sim \pi_k(t)$
- ➡ **Observe** game outcome

- ➡  $a_{-k}(t)$
- ➡  $u_k(a_k(t), a_{-k}(t))$

- ➡ **Improve**  $\pi_k(t+1)$

Thus, we can expect that  $\forall k \in K$

$$\pi_{k(t)} \xrightarrow{t \rightarrow \infty} \pi_k^* \quad (6)$$

$$u_k(\pi_k(t), \pi_{-k}(t)) \xrightarrow{t \rightarrow \infty} u_k(\pi_k^*, \pi_{-k}^*) \quad (7)$$

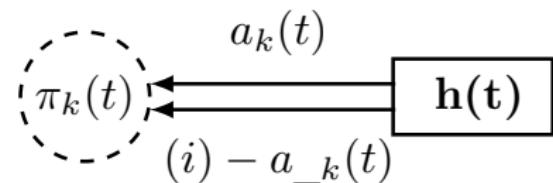


Figure 16. .

Where:

- ➡  $\pi^* = (\pi_1^*, \dots, \pi_k^*)$  is the NE strategy profile

# Outline

1. Introduction

2. State of the art

3. x-Testbed

4. x-Sentilo

5. x-Long paper

6. Genetic Algorithm For LoRa

7. EES

8. Template

9. UTLC

10. Conclusion

- 1. MADM
- 2. Learning
- 3. Fuzzy Logic**
- 4. Utility Function
- 5. Game Theory
- 6. Discussion

# Outline

1. Introduction

2. State of the art

3. x-Testbed

4. x-Sentilo

5. x-Long paper

6. Genetic Algorithm For LoRa

7. EES

8. Template

9. UTLC

10. Conclusion

1. MADM
2. Learning
3. Fuzzy Logic
- 4. Utility Function**
5. Game Theory
6. Discussion

# Outline

1. Introduction

2. State of the art

3. x-Testbed

4. x-Sentilo

5. x-Long paper

6. Genetic Algorithm For LoRa

7. EES

8. Template

9. UTLC

10. Conclusion

- 1. MADM
- 2. Learning
- 3. Fuzzy Logic
- 4. Utility Function
- 5. Game Theory**
- 6. Discussion

# Game theory

## Related work

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

# Outline

1. Introduction

2. State of the art

3. x-Testbed

4. x-Sentilo

5. x-Long paper

6. Genetic Algorithm For LoRa

7. EES

8. Template

9. UTLC

10. Conclusion

- 1. MADM
- 2. Learning
- 3. Fuzzy Logic
- 4. Utility Function
- 5. Game Theory
- 6. Discussion**

## Discussion

- ➡ a
- ➡ b

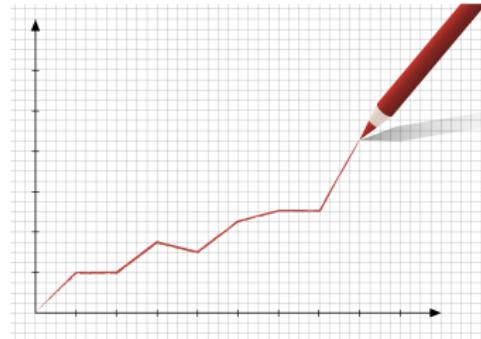


Figure 17. .

# Outline

1. Introduction
  2. State of the art
  3. x-Testbed
  4. x-Sentilo
  5. x-Long paper
  6. Genetic Algorithm For LoRa
  7. EES
  8. Template
  9. UTLC
  10. Conclusion
1. Problem statement
  2. Related work
  3. Contagion process
  4. Experimentation
  5. Results exploitation
  6. Discussion

# Outline

1. Introduction
  2. State of the art
  - 3. x-Testbed**
  4. x-Sentilo
  5. x-Long paper
  6. Genetic Algorithm For LoRa
  7. EES
  8. Template
  9. UTLC
  10. Conclusion
- 1. Problem statement**
  2. Related work
  3. Contagion process
  4. Experimentation
  5. Results exploitation
  6. Discussion

# Problem statement

## Introduction

- ➡ a
- ➡ b

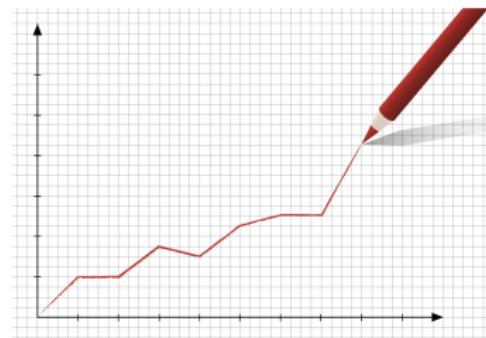


Figure 18. .

# Outline

1. Introduction
  2. State of the art
  - 3. x-Testbed**
  4. x-Sentilo
  5. x-Long paper
  6. Genetic Algorithm For LoRa
  7. EES
  8. Template
  9. UTLC
  10. Conclusion
1. Problem statement
  - 2. Related work**
  3. Contagion process
  4. Experimentation
  5. Results exploitation
  6. Discussion

## Related work

### Comparison

Paper	A1	A2	A3	A4

Table 4. An example table.

## Related work

### Comparison

Paper	A1	A2	A3	A4

Table 5. An example table.

# Outline

1. Introduction
  2. State of the art
  - 3. x-Testbed**
  4. x-Sentilo
  5. x-Long paper
  6. Genetic Algorithm For LoRa
  7. EES
  8. Template
  9. UTLC
  10. Conclusion
1. Problem statement
  2. Related work
  - 3. Contagion process**
  4. Experimentation
  5. Results exploitation
  6. Discussion

... (step 1)

Methods



... (step 2)

Methods



## ... (step 3)

### Methods



... (step 4)

Methods



# Results

## Comparison


Table 6

# Outline

1. Introduction
  2. State of the art
  - 3. x-Testbed**
  4. x-Sentilo
  5. x-Long paper
  6. Genetic Algorithm For LoRa
  7. EES
  8. Template
  9. UTLC
  10. Conclusion
1. Problem statement
  2. Related work
  3. Contagion process
  - 4. Experimentation**
  5. Results exploitation
  6. Discussion

# Experimentation

## Experimentation

- a
- b

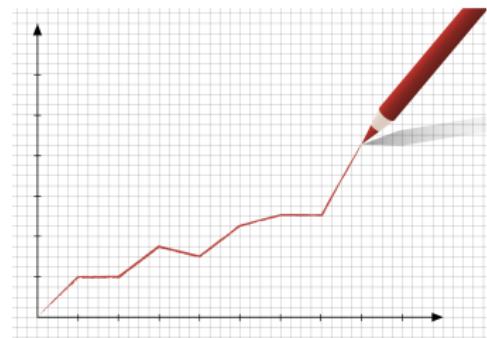


Figure 19. .

# Outline

1. Introduction
  2. State of the art
  - 3. x-Testbed**
  4. x-Sentilo
  5. x-Long paper
  6. Genetic Algorithm For LoRa
  7. EES
  8. Template
  9. UTLC
  10. Conclusion
1. Problem statement
  2. Related work
  3. Contagion process
  4. Experimentation
  - 5. Results exploitation**
  6. Discussion

# Results

## Comparison

- a
- b

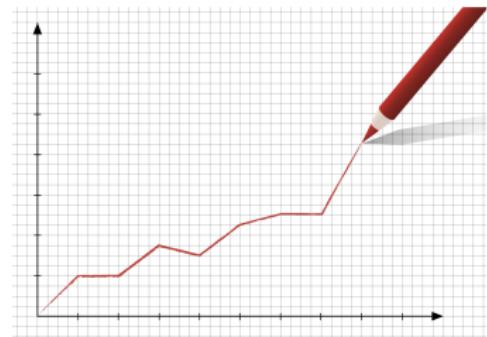


Figure 20. .

# Outline

1. Introduction
  2. State of the art
  - 3. x-Testbed**
  4. x-Sentilo
  5. x-Long paper
  6. Genetic Algorithm For LoRa
  7. EES
  8. Template
  9. UTLC
  10. Conclusion
1. Problem statement
  2. Related work
  3. Contagion process
  4. Experimentation
  5. Results exploitation
  - 6. Discussion**

## Discussion

- ▶ a
- ▶ b

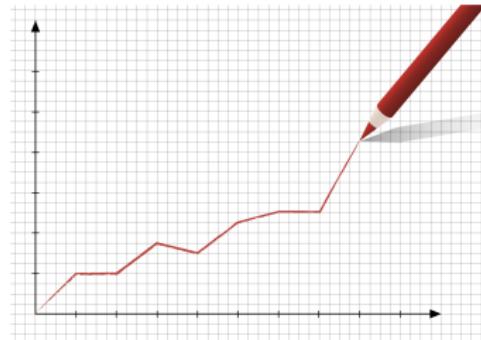


Figure 21. .

# Outline

1. Introduction
2. State of the art
3. x-Testbed
- 4. x-Sentilo**
  1. Problem statement
  2. Related work
  3. Contagion process
  4. Experimentation
  5. Results exploitation
  6. Discussion
5. x-Long paper
6. Genetic Algorithm For LoRa
7. EES
8. Template
9. UTLC
10. Conclusion

# Outline

1. Introduction

2. State of the art

3. x-Testbed

## 4. x-Sentilo

5. x-Long paper

6. Genetic Algorithm For LoRa

7. EES

8. Template

9. UTLC

10. Conclusion

### 1. Problem statement

2. Related work

3. Contagion process

4. Experimentation

5. Results exploitation

6. Discussion

# Problem statement

## Introduction

- ➡ a
- ➡ b

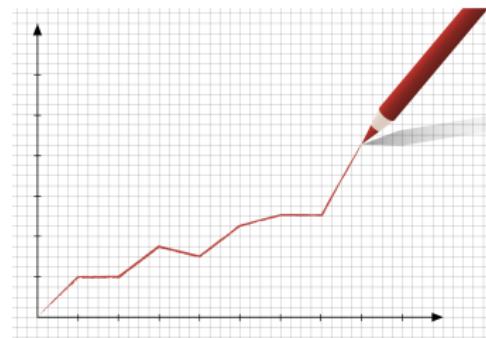


Figure 22. .

# Outline

1. Introduction

2. State of the art

3. x-Testbed

## 4. x-Sentilo

5. x-Long paper

6. Genetic Algorithm For LoRa

7. EES

8. Template

9. UTLC

10. Conclusion

1. Problem statement
2. Related work
3. Contagion process
4. Experimentation
5. Results exploitation
6. Discussion

## Related work

### Comparison

Paper	A1	A2	A3	A4

Table 7. An example table.

## Related work

### Comparison

Paper	A1	A2	A3	A4

Table 8. An example table.

# Outline

1. Introduction

2. State of the art

3. x-Testbed

## 4. x-Sentilo

5. x-Long paper

6. Genetic Algorithm For LoRa

7. EES

8. Template

9. UTLC

10. Conclusion

1. Problem statement
2. Related work
- 3. Contagion process**
4. Experimentation
5. Results exploitation
6. Discussion

## ... (step 2)

### Methods



... (step 3)

Methods



... (step 4)

Methods



# Results

## Comparison


Table 9

# Outline

1. Introduction

2. State of the art

3. x-Testbed

## 4. x-Sentilo

5. x-Long paper

6. Genetic Algorithm For LoRa

7. EES

8. Template

9. UTLC

10. Conclusion

1. Problem statement
2. Related work
3. Contagion process
- 4. Experimentation**
5. Results exploitation
6. Discussion

# Experimentation

## Experimentation

- a
- b

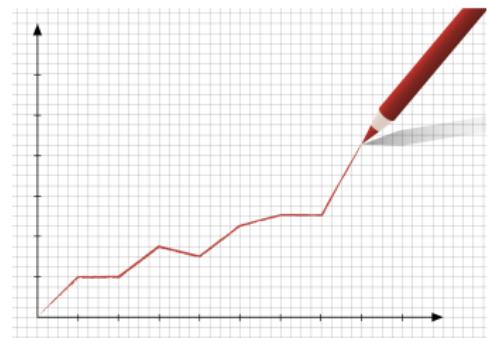


Figure 23. .

# Outline

1. Introduction

2. State of the art

3. x-Testbed

## 4. x-Sentilo

5. x-Long paper

6. Genetic Algorithm For LoRa

7. EES

8. Template

9. UTLC

10. Conclusion

1. Problem statement
2. Related work
3. Contagion process
4. Experimentation
- 5. Results exploitation**
6. Discussion

# Results

## Comparison

- a
- b

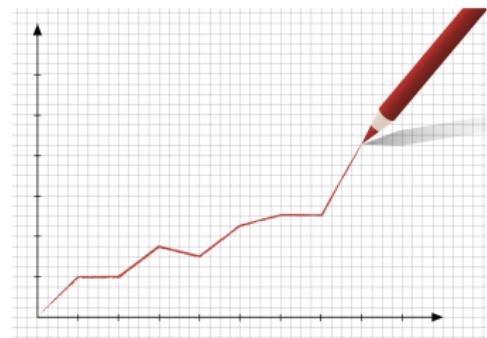


Figure 24. .

# Outline

1. Introduction

2. State of the art

3. x-Testbed

## 4. x-Sentilo

5. x-Long paper

6. Genetic Algorithm For LoRa

7. EES

8. Template

9. UTLC

10. Conclusion

1. Problem statement
2. Related work
3. Contagion process
4. Experimentation
5. Results exploitation
- 6. Discussion**

## Discussion

- ➡ a
- ➡ b

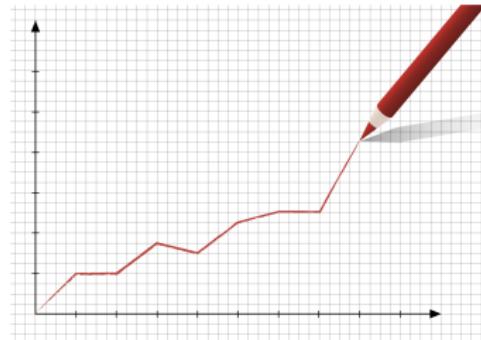


Figure 25. .

# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. x-Long paper
  1. Problem statement
  2. Related work
  3. Contagion process
  4. Experimentation
  5. Results exploitation
  6. Discussion
6. Genetic Algorithm For LoRa
7. EES
8. Template
9. UTLC
10. Conclusion

# Outline

1. Introduction
  2. State of the art
  3. x-Testbed
  4. x-Sentilo
  5. x-Long paper
  6. Genetic Algorithm For LoRa
  7. EES
  8. Template
  9. UTLC
  10. Conclusion
- 1. Problem statement**
2. Related work
3. Contagion process
4. Experimentation
5. Results exploitation
6. Discussion

# Problem statement

## Introduction

- ▶ a
- ▶ b

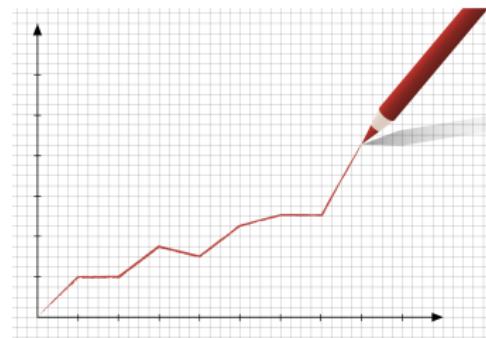


Figure 26. .

# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. x-Long paper
  1. Problem statement
  2. Related work
  3. Contagion process
  4. Experimentation
  5. Results exploitation
  6. Discussion
6. Genetic Algorithm For LoRa
7. EES
8. Template
9. UTLC
10. Conclusion

## Related work

### Comparison

Paper	A1	A2	A3	A4
[8]				

Table 10. An example table.

## Related work

### Comparison

Paper	A1	A2	A3	A4

Table 11. An example table.

# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. x-Long paper
  1. Problem statement
  2. Related work
  - 3. Contagion process**
  4. Experimentation
  5. Results exploitation
  6. Discussion
6. Genetic Algorithm For LoRa
7. EES
8. Template
9. UTLC
10. Conclusion

## ... (step 1)

### Methods



## ... (step 2)

### Methods



## ... (step 3)

### Methods



## ... (step 4)

### Methods



# Results

## Comparison


Table 12

# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. **x-Long paper**
  1. Problem statement
  2. Related work
  3. Contagion process
  - 4. Experimentation**
  5. Results exploitation
  6. Discussion
6. Genetic Algorithm For LoRa
7. EES
8. Template
9. UTLC
10. Conclusion

# Experimentation

## Experimentation

- a
- b

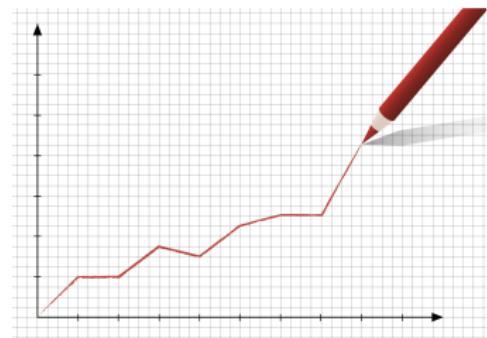


Figure 27. .

# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. **x-Long paper**
  1. Problem statement
  2. Related work
  3. Contagion process
  4. Experimentation
  - 5. Results exploitation**
  6. Discussion
6. Genetic Algorithm For LoRa
7. EES
8. Template
9. UTLC
10. Conclusion

# Results

## Comparison

- a
- b

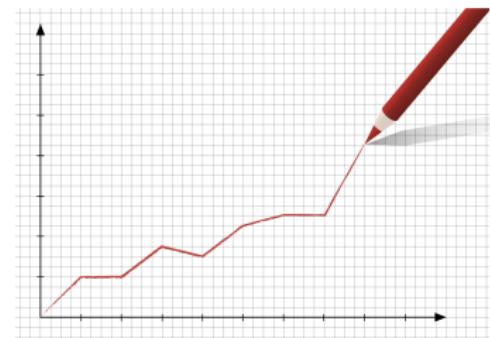


Figure 28. .

# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. **x-Long paper**
  1. Problem statement
  2. Related work
  3. Contagion process
  4. Experimentation
  5. Results exploitation
  6. **Discussion**
6. Genetic Algorithm For LoRa
7. EES
8. Template
9. UTLC
10. Conclusion

## Discussion

- ➡ a
- ➡ b

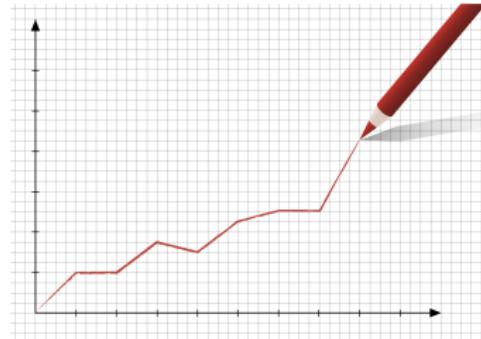


Figure 29. .

# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. x-Long paper
6. Genetic Algorithm For LoRa
  1. Problem statement
  2. Related work
  3. Background
  4. Method
  5. Experimentation
  6. Results
  7. Discussion
7. EES
8. Template
9. UTLC
10. Conclusion

# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. x-Long paper
6. Genetic Algorithm For LoRa
  - 1. Problem statement
  - 2. Related work
  - 3. Background
  - 4. Method
  - 5. Experimentation
  - 6. Results
  - 7. Discussion
7. EES
8. Template
9. UTLC
10. Conclusion

# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. x-Long paper
6. **Genetic Algorithm For LoRa**
  1. Problem statement
  - 2. Related work**
  3. Background
  4. Method
  5. Experimentation
  6. Results
  7. Discussion
7. EES
8. Template
9. UTLC
10. Conclusion

# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. x-Long paper
6. **Genetic Algorithm For LoRa**
  1. Problem statement
  2. Related work
  - 3. Background**
  4. Method
  5. Experimentation
  6. Results
  7. Discussion
7. EES
8. Template
9. UTLC
10. Conclusion

# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. x-Long paper
6. **Genetic Algorithm For LoRa**
  1. Problem statement
  2. Related work
  3. Background
  - 4. Method**
  5. Experimentation
  6. Results
  7. Discussion
7. EES
8. Template
9. UTLC
10. Conclusion

## ... (step 2)

### Methods

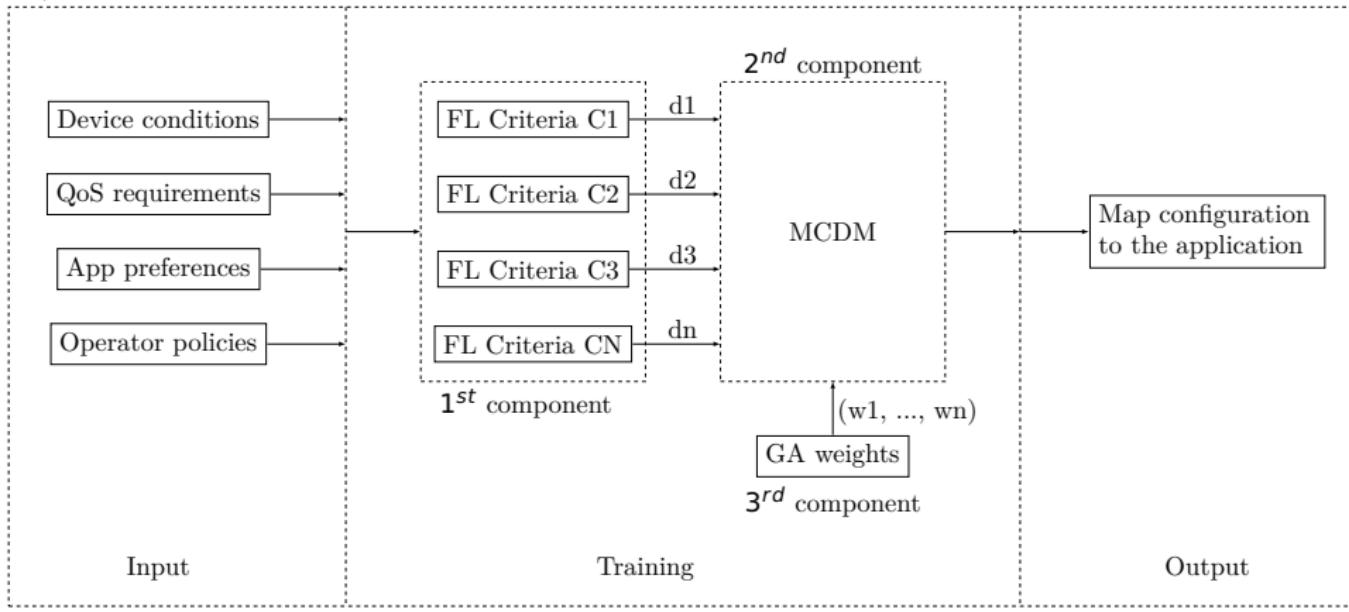


Figure 30. HH.

... (step 3)

Methods



... (step 4)

Methods



# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. x-Long paper
6. **Genetic Algorithm For LoRa**
  1. Problem statement
  2. Related work
  3. Background
  4. Method
  - 5. Experimentation**
  6. Results
  7. Discussion
7. EES
8. Template
9. UTLC
10. Conclusion

# Experimentation

## Experimentation

- a
- b

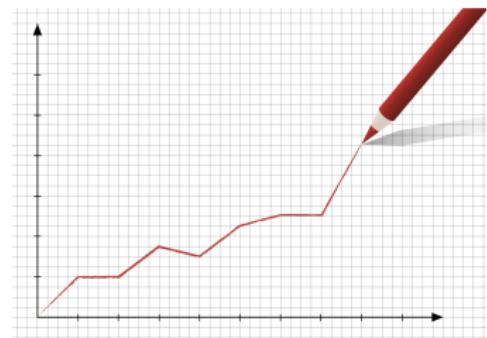


Figure 31. .

# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. x-Long paper
6. **Genetic Algorithm For LoRa**
  1. Problem statement
  2. Related work
  3. Background
  4. Method
  5. Experimentation
  - 6. Results**
  7. Discussion
7. EES
8. Template
9. UTLC
10. Conclusion

# Results

## Comparison

- a
- b

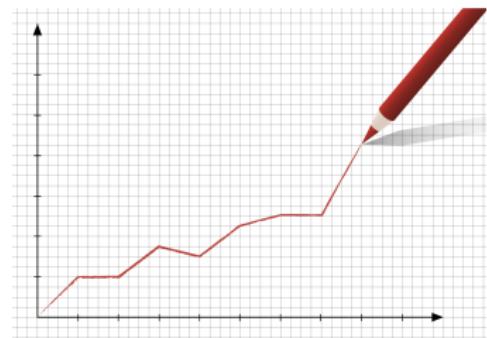


Figure 32. .

# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. x-Long paper
6. **Genetic Algorithm For LoRa**
  1. Problem statement
  2. Related work
  3. Background
  4. Method
  5. Experimentation
  6. Results
  7. Discussion
7. EES
8. Template
9. UTLC
10. Conclusion

## Discussion

- ▶ a
- ▶ b

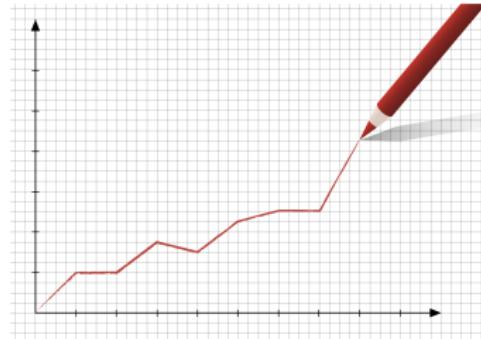


Figure 33. .

# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. x-Long paper
  1. Problem statement
  2. Related work
  3. Contagion process
  4. Experimentation
  5. Results exploitation
  6. Discussion
6. Genetic Algorithm For LoRa
7. EES
8. Template
9. UTLC
10. Conclusion

# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. x-Long paper
6. Genetic Algorithm For LoRa
- 7. EES**
  1. Problem statement
  2. Related work
  3. Contagion process
  4. Experimentation
  5. Results exploitation
  6. Discussion
8. Template
9. UTLC
10. Conclusion

# Problem statement

## Introduction

- ➡ a
- ➡ b

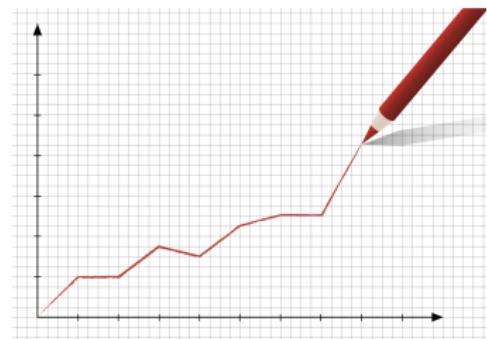


Figure 34. .

# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. x-Long paper
6. Genetic Algorithm For LoRa
- 7. EES**
  1. Problem statement
  - 2. Related work**
  3. Contagion process
  4. Experimentation
  5. Results exploitation
  6. Discussion
8. Template
9. UTLC
10. Conclusion

## Related work

### Comparison

Paper	A1	A2	A3	A4

Table 13. An example table.

## Related work

### Comparison

Paper	A1	A2	A3	A4

Table 14. An example table.

# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. x-Long paper
6. Genetic Algorithm For LoRa
- 7. EES**
  1. Problem statement
  2. Related work
  - 3. Contagion process**
  4. Experimentation
  5. Results exploitation
  6. Discussion
8. Template
9. UTLC
10. Conclusion

... (step 1)

Methods



... (step 2)

Methods



... (step 3)

Methods



... (step 4)

Methods



# Results

## Comparison


Table 15

# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. x-Long paper
6. Genetic Algorithm For LoRa
- 7. EES**
  1. Problem statement
  2. Related work
  3. Contagion process
  - 4. Experimentation**
  5. Results exploitation
  6. Discussion
8. Template
9. UTLC
10. Conclusion

# Experimentation

## Experimentation

- a
- b

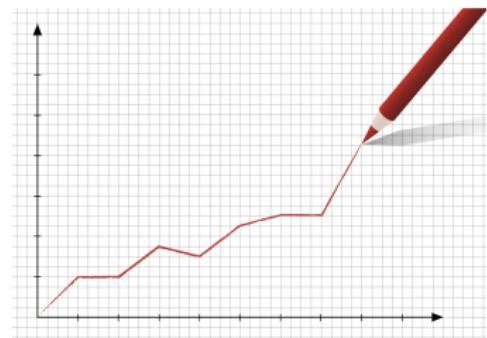


Figure 35. .

# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. x-Long paper
  1. Problem statement
  2. Related work
  3. Contagion process
  4. Experimentation
  - 5. Results exploitation**
  6. Discussion
6. Genetic Algorithm For LoRa
7. EES
8. Template
9. UTLC
10. Conclusion

# Results

## Comparison

- ▶ a
- ▶ b

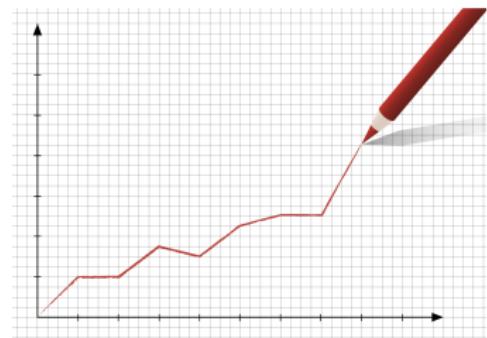


Figure 36. .

# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. x-Long paper
  1. Problem statement
  2. Related work
  3. Contagion process
  4. Experimentation
  5. Results exploitation
  6. Discussion
6. Genetic Algorithm For LoRa
7. EES
8. Template
9. UTLC
10. Conclusion

## Discussion

- ▶ a
- ▶ b

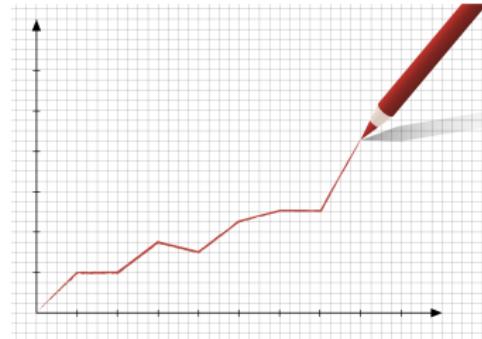


Figure 37. .

# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. x-Long paper
  1. Problem statement
  2. Related work
  3. Contagion process
  4. Experimentation
  5. Results exploitation
  6. Discussion
6. Genetic Algorithm For LoRa
7. EES
8. Template
9. UTLC
10. Conclusion

# Outline

1. Introduction
  2. State of the art
  3. x-Testbed
  4. x-Sentilo
  5. x-Long paper
  6. Genetic Algorithm For LoRa
  7. EES
  - 8. Template**
  9. UTLC
  10. Conclusion
- 1. Problem statement**
  2. Related work
  3. Contagion process
  4. Experimentation
  5. Results exploitation
  6. Discussion

# Problem statement

## Introduction

- ➡ a
- ➡ b

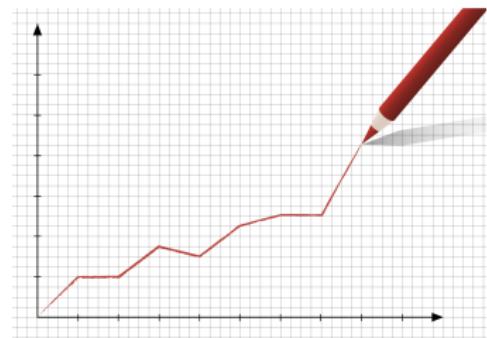


Figure 38. .

# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. x-Long paper
  1. Problem statement
  - 2. Related work**
  3. Contagion process
  4. Experimentation
  5. Results exploitation
  6. Discussion
6. Genetic Algorithm For LoRa
7. EES
- 8. Template**
9. UTLC
10. Conclusion

## Related work

### Comparison

Paper	A1	A2	A3	A4

Table 16. An example table.

## Related work

### Comparison

Paper	A1	A2	A3	A4

Table 17. An example table.

# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. x-Long paper
6. Genetic Algorithm For LoRa
  1. Problem statement
  2. Related work
  - 3. Contagion process**
  4. Experimentation
  5. Results exploitation
  6. Discussion
7. EES
- 8. Template**
9. UTLC
10. Conclusion

... (step 1)

Methods



## ... (step 2)

### Methods



... (step 3)

Methods



... (step 4)

Methods



# Results

## Comparison


Table 18

# Outline

1. Introduction
  2. State of the art
  3. x-Testbed
  4. x-Sentilo
  5. x-Long paper
  6. Genetic Algorithm For LoRa
  7. EES
  - 8. Template**
  9. UTLC
  10. Conclusion
1. Problem statement
  2. Related work
  3. Contagion process
  - 4. Experimentation**
  5. Results exploitation
  6. Discussion

# Experimentation

## Experimentation

- a
- b

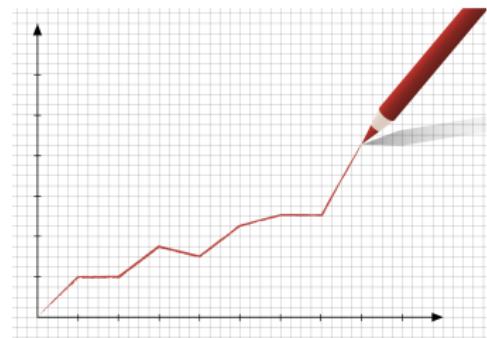


Figure 39. .

# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. x-Long paper
  1. Problem statement
  2. Related work
  3. Contagion process
  4. Experimentation
  - 5. Results exploitation**
  6. Discussion
6. Genetic Algorithm For LoRa
7. EES
- 8. Template**
9. UTLC
10. Conclusion

# Results

## Comparison

- a
- b

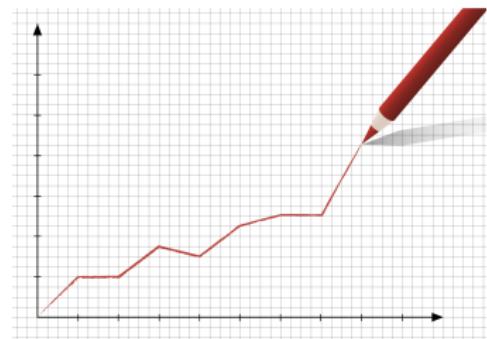


Figure 40. .

# Outline

1. Introduction
  2. State of the art
  3. x-Testbed
  4. x-Sentilo
  5. x-Long paper
  6. Genetic Algorithm For LoRa
  7. EES
  - 8. Template**
  9. UTLC
  10. Conclusion
1. Problem statement
  2. Related work
  3. Contagion process
  4. Experimentation
  5. Results exploitation
  - 6. Discussion**

## Discussion

- ➡ a
- ➡ b

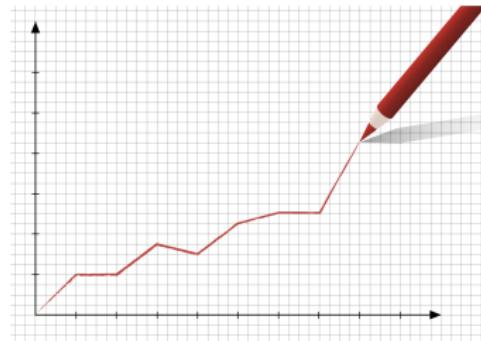


Figure 41. .

# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. x-Long paper
  1. Problem statement
  2. Related work
  3. Contagion process
  4. Experimentation
  5. Results exploitation
  6. Discussion
6. Genetic Algorithm For LoRa
7. EES
8. Template
9. UTLC
10. Conclusion

# Outline

1. Introduction
  2. State of the art
  3. x-Testbed
  4. x-Sentilo
  5. x-Long paper
  6. Genetic Algorithm For LoRa
  7. EES
  8. Template
  - 9. UTLC**
  10. Conclusion
- 1. Problem statement**
  2. Related work
  3. Contagion process
  4. Experimentation
  5. Results exploitation
  6. Discussion

# Problem statement

## Introduction

- ▶ a
- ▶ b

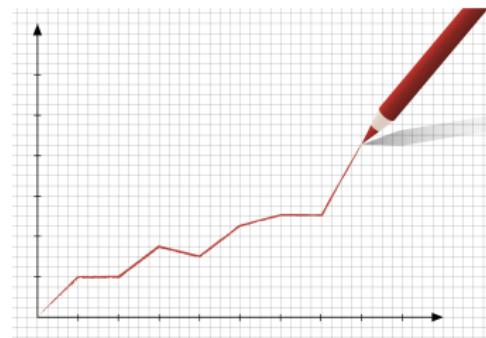


Figure 42. .

# Outline

1. Introduction
  2. State of the art
  3. x-Testbed
  4. x-Sentilo
  5. x-Long paper
  6. Genetic Algorithm For LoRa
  7. EES
  8. Template
  - 9. UTLC**
  10. Conclusion
1. Problem statement
  - 2. Related work**
  3. Contagion process
  4. Experimentation
  5. Results exploitation
  6. Discussion

## Related work

### Comparison

Paper	A1	A2	A3	A4

Table 19. An example table.

## Related work

### Comparison

Paper	A1	A2	A3	A4

Table 20. An example table.

# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. x-Long paper
6. Genetic Algorithm For LoRa
  1. Problem statement
  2. Related work
  - 3. Contagion process**
  4. Experimentation
  5. Results exploitation
  6. Discussion
7. EES
8. Template
- 9. UTLC**
10. Conclusion

... (step 1)

Methods



... (step 2)

Methods



... (step 3)

Methods



... (step 4)

Methods



# Results

## Comparison


Table 21



# Outline

1. Introduction
  2. State of the art
  3. x-Testbed
  4. x-Sentilo
  5. x-Long paper
  6. Genetic Algorithm For LoRa
  7. EES
  8. Template
  - 9. UTLC**
  10. Conclusion
1. Problem statement
  2. Related work
  3. Contagion process
  - 4. Experimentation**
  5. Results exploitation
  6. Discussion

# Experimentation

## Experimentation

- a
- b

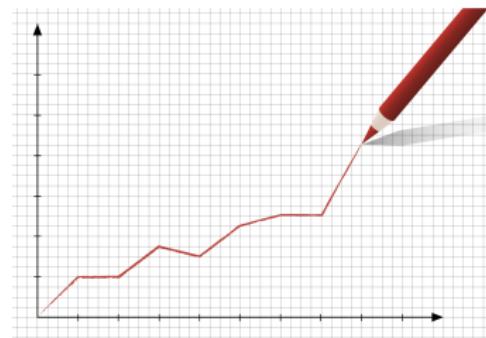


Figure 43. .

# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. x-Long paper
  1. Problem statement
  2. Related work
  3. Contagion process
  4. Experimentation
  - 5. Results exploitation**
  6. Discussion
6. Genetic Algorithm For LoRa
7. EES
8. Template
- 9. UTLC**
10. Conclusion

# Results

## Comparison

- a
- b

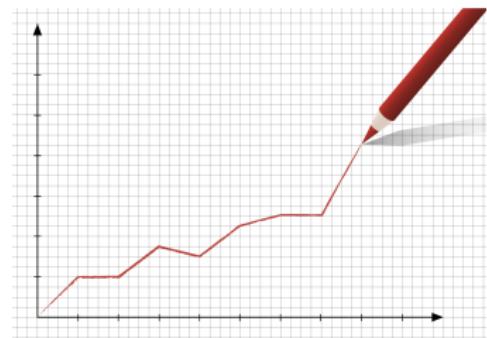


Figure 44. .

# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. x-Long paper
  1. Problem statement
  2. Related work
  3. Contagion process
  4. Experimentation
  5. Results exploitation
  - 6. Discussion**
6. Genetic Algorithm For LoRa
7. EES
8. Template
- 9. UTLC**
10. Conclusion

## Discussion

- ➡ a
- ➡ b

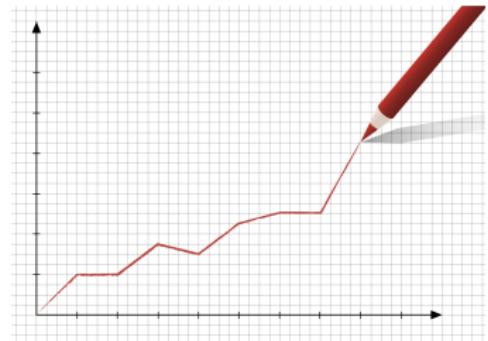


Figure 45. .

# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. x-Long paper
6. Genetic Algorithm For LoRa
7. EES
8. Template
9. UTLC
10. Conclusion

## Conclusion

Our main goal was

- ▶ .
- ▶ .

Our main contribution was

- ▶ .
- ▶ .

Our main results was

- ▶ .
- ▶ .

# Future Challenges

## Conclusion

Our future goal was

- ➡ .
- ➡ .
- ➡ .

# Outline

1. Introduction
2. State of the art
3. x-Testbed
4. x-Sentilo
5. x-Long paper
6. Genetic Algorithm For LoRa
7. EES
8. Template
9. UTLC
10. Conclusion

# References

- [2] D. E. Kouicem, A. Bouabdallah, and H. Lakhlef, " Internet of Things Security: A Top-down Survey ", *Computer Networks*, vol. 141, pp. 199–221, Aug. 4, 2018, 00029.
- [3] V. P. Venkatesan, C. P. Devi, and M. Sivarajanji, " Design of a Smart Gateway Solution Based on the Exploration of Specific Challenges in IoT ", in *2017 International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC)*, 00004, Palladam, Tamilnadu, India: IEEE, Feb. 2017, pp. 22–31.
- [4] L. Feltrin, C. Buratti, E. Vinciarelli, R. De Bonis, and R. Verdone, " LoRaWAN: Evaluation of Link- and System-Level Performance ", *IEEE Internet of Things Journal*, vol. 5, no. 3, pp. 2249–2258, Jun. 2018, 00018.
- [5] 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.
- [8] P. A. Barro, " A LoRaWAN Coverage testBed and a Multi-Optional Communication Architecture for Smart City Feasibility in Developing Countries ", p. 12, 2019, 00000.
- [6] V. Sciancalepore, M. Di Renzo, and X. Costa-Perez, " STORNS: Stochastic Radio Access Network Slicing ", Jan. 16, 2019, 00001. arXiv: 1901.05336 [cs, math].
- [7] A. Ksentini and N. Nikaein, " Toward Enforcing Network Slicing on RAN: Flexibility and Resources Abstraction ", *IEEE Communications Magazine*, vol. 55, no. 6, pp. 102–108, 2017, 00063.
- [1] C. Perera, P. P. Jayaraman, A. Zaslavsky, P. Christen, and D. Georgakopoulos, " MOSDEN: An Internet of Things Middleware for Resource Constrained Mobile Devices ", Oct. 15, 2013, 00107. arXiv: 1310.4038 [cs].