

## Setup the environment

```
! wget https://www.lancaster.ac.uk/scc/sites/lora/lorasim-20170710.tgz
! tar -xvf lorasim-20170710.tgz
```

```
!sudo apt-get install python2 && curl
https://bootstrap.pypa.io/pip/2.7/get-pip.py -o get-pip.py && python2
get-pip.py && rm get-pip.py
!sudo apt install python-tk
!pip2 install -r 'lorasim/requirements.txt'
```

```
--2025-04-24 10:37:27--
```

```
https://www.lancaster.ac.uk/scc/sites/lora/lorasim-20170710.tgz
Resolving www.lancaster.ac.uk (www.lancaster.ac.uk)... 148.88.65.80,
2001:630:80:2ff::80:1
Connecting to www.lancaster.ac.uk (www.lancaster.ac.uk)|
148.88.65.80|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 112640 (110K) [application/x-gzip]
Saving to: 'lorasim-20170710.tgz.1'
```

```
lorasim-20170710.tg 100%[=====>] 110.00K 408KB/s in
0.3s
```

```
2025-04-24 10:37:28 (408 KB/s) - 'lorasim-20170710.tgz.1' saved
[112640/112640]
```

```
lorasim/
lorasim/loraDir.py
lorasim/loraDirMulBS.py
lorasim/oneDirectionalLoraIntf.py
lorasim/requirements.txt
```

```
lorasim/directionalLoraIntf.py
```

```
Reading package lists... Done
```

```
Building dependency tree... Done
```

```
Reading state information... Done
```

```
python2 is already the newest version (2.7.18-3).
```

```
0 upgraded, 0 newly installed, 0 to remove and 34 not upgraded.
```

% Total	% Received	% Xferd	Average Speed	Time	Time	Time
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Speed

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--:--:-- 8470k

```
Collecting pip<21.0
```

```
Using cached pip-20.3.4-py2.py3-none-any.whl (1.5 MB)
```

```
Installing collected packages: pip
```

```
Attempting uninstall: pip
```

```
Found existing installation: pip 20.3.4
```

```
Uninstalling pip-20.3.4:
  Successfully uninstalled pip-20.3.4
Successfully installed pip-20.3.4
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
python-tk is already the newest version (2.7.18-1build1).
0 upgraded, 0 newly installed, 0 to remove and 34 not upgraded.
Requirement already satisfied: numpy==1.11.1 in
/usr/local/lib/python2.7/dist-packages (from -r
lorasim/requirements.txt (line 1)) (1.11.1)
Requirement already satisfied: simpy==3.0.10 in
/usr/local/lib/python2.7/dist-packages (from -r
lorasim/requirements.txt (line 2)) (3.0.10)
Requirement already satisfied: matplotlib==2.0.0 in
/usr/local/lib/python2.7/dist-packages (from -r
lorasim/requirements.txt (line 3)) (2.0.0)
Requirement already satisfied: six>=1.10 in
/usr/local/lib/python2.7/dist-packages (from matplotlib==2.0.0->-r
lorasim/requirements.txt (line 3)) (1.17.0)
Requirement already satisfied: python-dateutil in
/usr/local/lib/python2.7/dist-packages (from matplotlib==2.0.0->-r
lorasim/requirements.txt (line 3)) (2.9.0.post0)
Requirement already satisfied: pytz in /usr/local/lib/python2.7/dist-
packages (from matplotlib==2.0.0->-r lorasim/requirements.txt (line
3)) (2025.2)
Requirement already satisfied: functools32 in
/usr/local/lib/python2.7/dist-packages (from matplotlib==2.0.0->-r
lorasim/requirements.txt (line 3)) (3.2.3.post2)
Requirement already satisfied: cycler>=0.10 in
/usr/local/lib/python2.7/dist-packages (from matplotlib==2.0.0->-r
lorasim/requirements.txt (line 3)) (0.10.0)
Requirement already satisfied: pyparsing!=2.0.0,!=2.0.4,!=2.1.2,!
=2.1.6,>=1.5.6 in /usr/local/lib/python2.7/dist-packages (from
matplotlib==2.0.0->-r lorasim/requirements.txt (line 3)) (2.4.7)
Requirement already satisfied: subprocess32 in
/usr/local/lib/python2.7/dist-packages (from matplotlib==2.0.0->-r
lorasim/requirements.txt (line 3)) (3.5.4)
```

## Play with the simulator

### Import libraries

```
import os
import pandas as pd
import math
```

## Execute simulations

```
import subprocess

def simulate(n_nodes, tx_rate, exp, duration):
    env = os.environ.copy()
    env["MPLBACKEND"] = "Agg"

    result = subprocess.run(
        [
            "python2",
            "lorasim/loradir.py",
            str(int(n_nodes)),
            str(int(tx_rate)),
            str(int(exp)),
            str(int(duration)),
            str(int(1))
        ],
        env=env,
        capture_output=True,
        text=True,
    )

duration = 86400000 # 1 day in ms
tx_rate = 1e6      #each node transmit a packet every 1000 seconds on
average (ms)
for n_nodes in list(range(0,50))+list(range(50, 300, 50)) +
list(range(300, 1601, 100)):
    print(f"Simulating {n_nodes} nodes")
    simulate(n_nodes, tx_rate, 4, duration)
    simulate(n_nodes, tx_rate, 3, duration)
    simulate(n_nodes, tx_rate, 5, duration)

Simulating 0 nodes
Simulating 1 nodes
Simulating 2 nodes
Simulating 3 nodes
Simulating 4 nodes
Simulating 5 nodes
Simulating 6 nodes
Simulating 7 nodes
Simulating 8 nodes
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Simulating 400 nodes  
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Simulating 1000 nodes  
Simulating 1100 nodes  
Simulating 1200 nodes  
Simulating 1300 nodes  
Simulating 1400 nodes

Simulating 1500 nodes

Simulating 1600 nodes

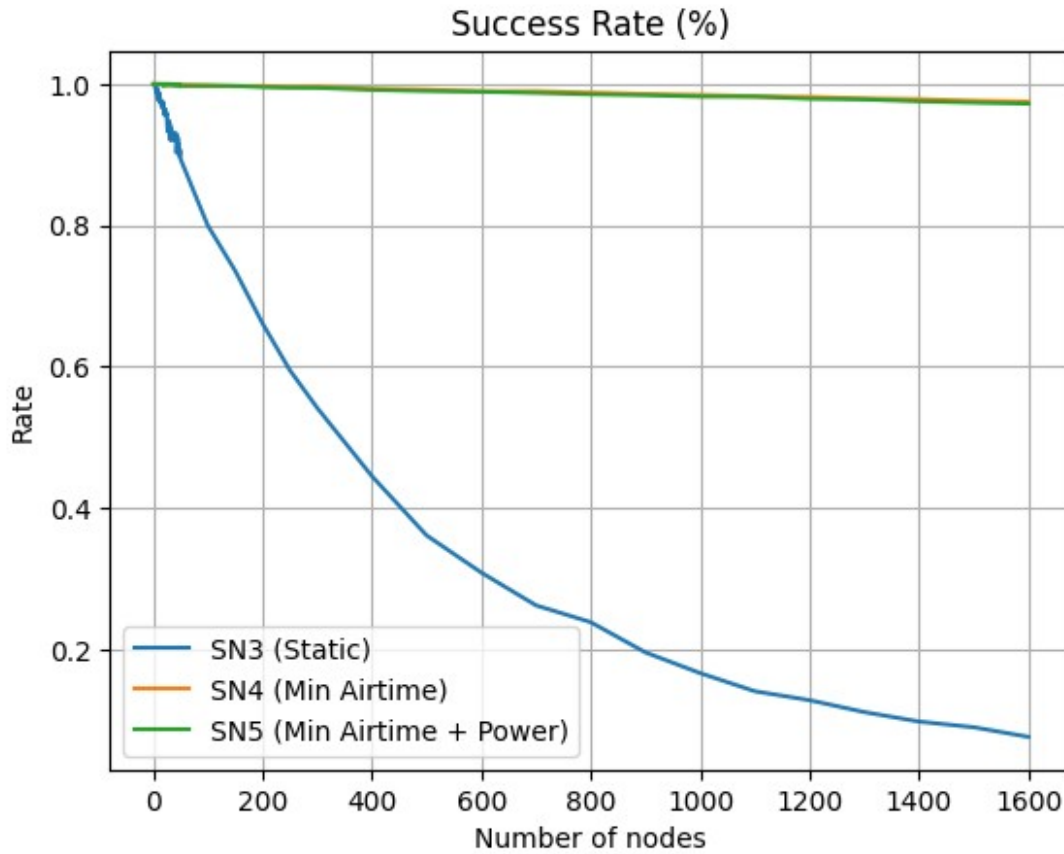
```
datasn3 = pd.read_csv("exp4.dat", sep=" ")
datasn4 = pd.read_csv("exp3.dat", sep=" ")
datasn5 = pd.read_csv("exp5.dat", sep=" ")

datasn3["der"] = (datasn3["nrTransmissions"] -
datasn3["nrCollisions"]) / datasn3["nrTransmissions"]
datasn4["der"] = (datasn4["nrTransmissions"] -
datasn4["nrCollisions"]) / datasn4["nrTransmissions"]
datasn5["der"] = (datasn5["nrTransmissions"] -
datasn5["nrCollisions"]) / datasn5["nrTransmissions"]

import matplotlib
import matplotlib.pyplot as plt

plt.plot(datasn3["#nrNodes"], datasn3["der"], linestyle='--',
label='SN3 (Static)')
plt.plot(datasn4["#nrNodes"], datasn4["der"], linestyle='--',
label='SN4 (Min Airtime)')
plt.plot(datasn5["#nrNodes"], datasn5["der"], linestyle='--',
label='SN5 (Min Airtime + Power)')

plt.title("Success Rate (%)")
plt.xlabel("Number of nodes")
plt.ylabel("Rate")
plt.legend()
plt.grid()
plt.show()
```



Second part - Figure 7 of the paper

```
import os
import subprocess

def simulate2(n_nodes, avg_send_time, exp, duration, nr_bs,
collision=1):
    env = os.environ.copy()
    env["MPLBACKEND"] = "Agg"

    subprocess.run(
        [
            "python2",
            "/content/lorasim/loraDirMulBS.py",
            str(int(n_nodes)),
            str(int(avg_send_time)),
            str(int(exp)),
            str(int(duration)),
            str(int(nr_bs)),
            str(int(collision)),
        ],
        env=env,
        capture_output=True,
```

```

        text=True,
    )

duration = 86400000 # 1 day in ms
tx_rate = 1e6
nr_bs_list = [1, 2, 3, 4, 8, 24]
exp = 0 # SN1

# Esecuzione simulazioni
for nr_bs in nr_bs_list:
    print(f"\n=== Simulazioni per {nr_bs} base station(s) ===")
    for n_nodes in list(range(0,50))+list(range(50, 300, 50)) +
list(range(300, 1601, 100)):
        print(f"→ Simulating {n_nodes} nodes...")
        simulate2(n_nodes, tx_rate, exp, duration, nr_bs, 1)

=== Simulazioni per 1 base station(s) ===
→ Simulating 0 nodes...
→ Simulating 1 nodes...
→ Simulating 2 nodes...
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```
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```

```
=== Simulazioni per 2 base station(s) ===
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→ Simulating 0 nodes...
→ Simulating 1 nodes...
→ Simulating 2 nodes...
→ Simulating 3 nodes...
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=== Simulazioni per 3 base station(s) ===

- Simulating 0 nodes...
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=== Simulazioni per 4 base station(s) ===

- Simulating 0 nodes...
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=== Simulazioni per 8 base station(s) ===

- Simulating 0 nodes...
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=== Simulazioni per 24 base station(s) ===

- Simulating 0 nodes...
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- Simulating 1500 nodes...
- Simulating 1600 nodes...

```

import pandas as pd
import matplotlib.pyplot as plt

nr_bs_list = [1, 2, 3, 4, 8, 24] # Numero di sink simulati
exp = 0 # Esperimento usato per generare i file
colors = ['b', 'g', 'r', 'c', 'm', 'orange']
markers = ['o', 's', '^', 'd', '*', 'x']

plt.figure(figsize=(10, 6))

for i, nr_bs in enumerate(nr_bs_list):
    fname = f"exp{exp}BS{nr_bs}.dat"
    try:
        df = pd.read_csv(fname, sep=" ", comment="#",
names=["nrNodes", "DER"])

        # Plot
        plt.plot(
            df["nrNodes"], df["DER"],
            label=f"{nr_bs} Sink{'s' if nr_bs > 1 else ''}",
            linestyle='-',
            marker=markers[i % len(markers)],
            color=colors[i % len(colors)],
        )
    except Exception as e:
        print(f"Errore con il file {fname}: {e}")

plt.title("DER vs Number of Nodes per Sink Configuration")
plt.xlabel("Number of Nodes")
plt.ylabel("Data Extraction Rate (DER)")
plt.grid(True)
plt.legend(title="Base Stations")
plt.ylim(0, 1.05)
plt.tight_layout()
plt.show()

```



