Using FIT/CorteXlab for the Evaluation of Access Policies in Dense IoT Networks through S3CAP, a New Modular Framework

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Multiple access in IoT

- IoT projections: the number of devices will more than double in the next years.
- Big problem to solve: huge number of devices sending very small packets in the uplink
- ALOHA-style medium access policies will become less viable for crowded IoT networks
- Collisions and re-transmissions: increased latency, higher energy consumption and shorter device battery life
- Going beyond simulations: inaccurate capture of interference patterns - real transmissions and repeatability

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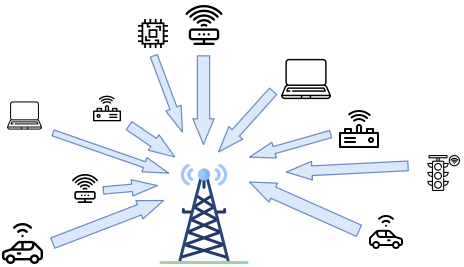
- Collisions and re-transmissions: increased latency, higher energy consumption and shorter device battery life
- Going beyond simulations: inaccurate capture of interference patterns - real transmissions and repeatability
- Our response to this need: Slotted-Synchronized multi-Source framework for experimentation on Channel Access Policies

S3-CAP framework

S3-CAP framework

- **Channel access policies**
  Development and evaluation of new channel access policies
- **Robust coding at the transmitter**
  Study of interference, non-orthogonal communication, error-correcting systems
- **Improved multi-level receiver**
  Successive interference cancellation, joint decoding



Presentation Outline

1. FIT/CorteXlab testbed
2. Framework implementation
3. Usage

FIT/CorteXlab testbed

FIT/CorteXlab

- Future Internet of Things - COgnitive Radio Testbed and EXperimentation LAB
- 180m^2 shielded and semi-anechoized experimentation room: at least 60dB isolation
- 40 software defined radios among USRPs and PicoSDRs, all GNU Radio compatible
- Reproducible experiments: stable propagation environment exempt from outside interference
- Dockerized operation: any version of GNU Radio can be used (as well as any other UHD based code)
- Octoclocks: full synchronization of USRPs is possible
- **Free to use** and remotely accessible over the internet (https://wiki.cortexlab.fr)

Figure: USRP NI-2932, USRP N2944R, PicoSDR, Octoclock


PSDR 2x2 41
PSDR 2x2 42
PSDR 4x4 22
USRP N2932 24
PSDR 2x2 26
USRP N2932 28
USRP N2944 30
USRP N2932 32
USRP N2932 34
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PSDR 2x2 2
USRP N2932 4
USRP N2932 6
USRP N2932 8
USRP N2944 10
PSDR 2x2 12
USRP N2932 14
USRP N2932 16
USRP N2932 18
PSDR 2x2 20
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USRP N2932 3
PSDR 2x2 5
USRP N2932 7
USRP N2932 9
USRP N2944 11
USRP N2932 13
PSDR 2x2 15
USRP N2932 17
PSDR 4x4 19

Opportunities with FIT/CorteXlab

- Research! Test your multi-radio techniques and architectures in FIT/CorteXlab
- Teaching: Radio, propagation, etc.. lab sessions (during confinements)
- Learn GNU Radio and USRP operation autonomously: GNU Radio's or CorteXlab's tutorials
- Automated test for validation of UHD and GNU Radio code on actual hardware
- Any other usage you may think of...

S3_CAP framework

Framework Layout

Uplink channel access

- Access policies;
- Robust coding.

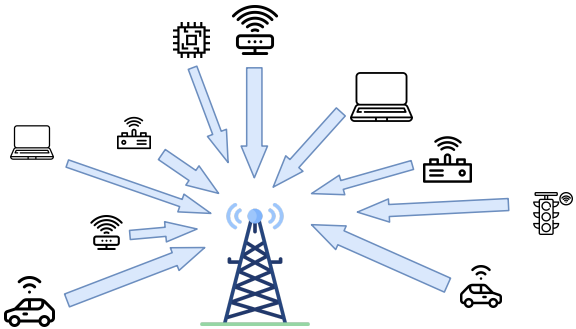

Figure: A star system

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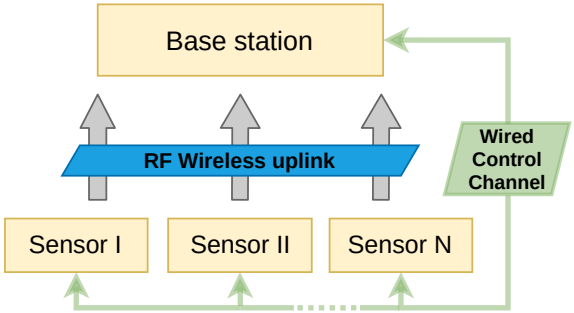
RF uplink channel

- Time framed;
- Slotted.



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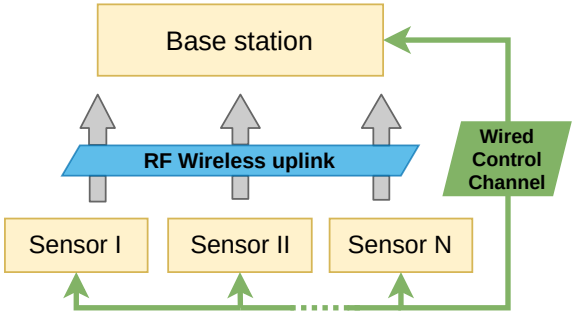
Wired control channel

- Uplink;
- Downlink;
- Error-free.



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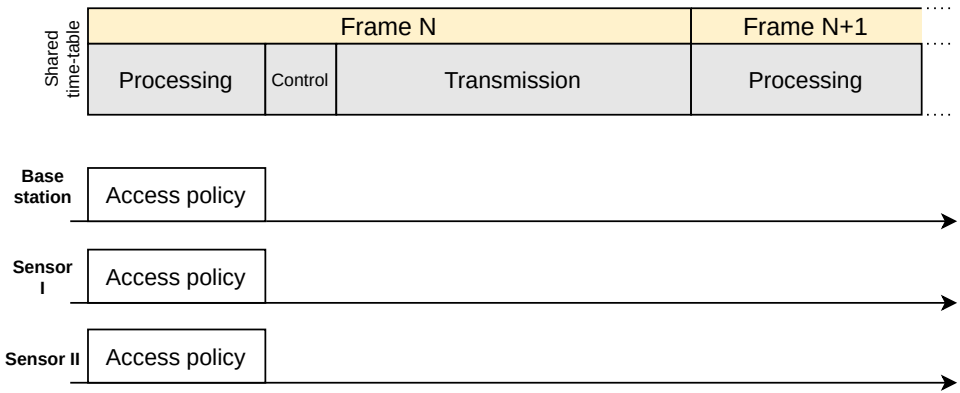

Figure: Shared time table

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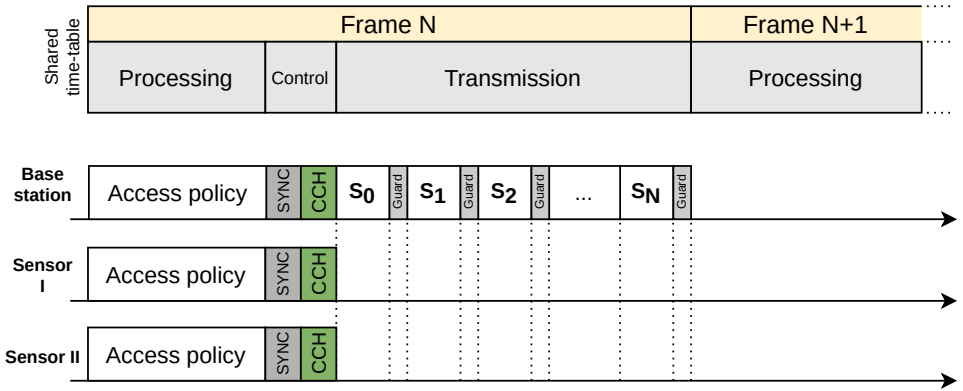

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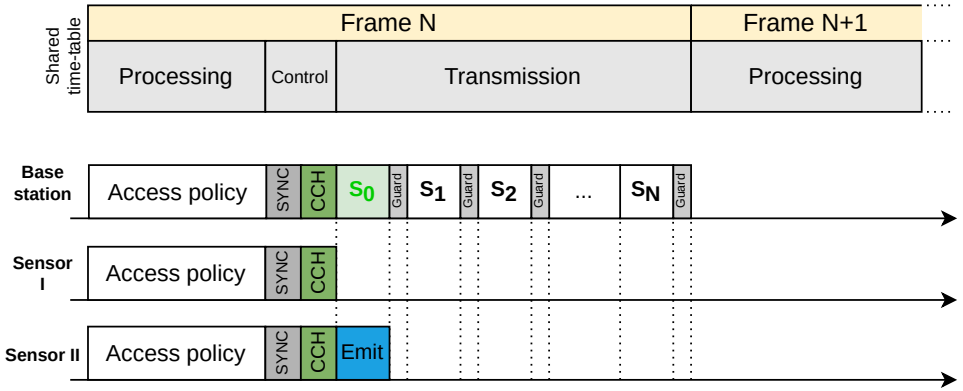

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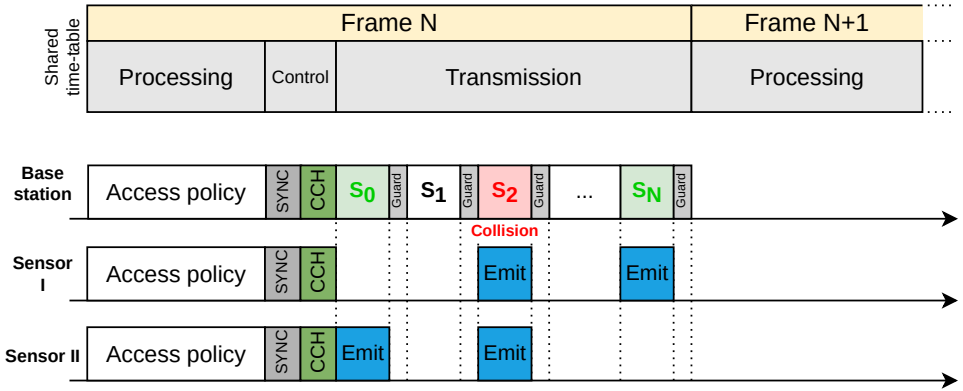

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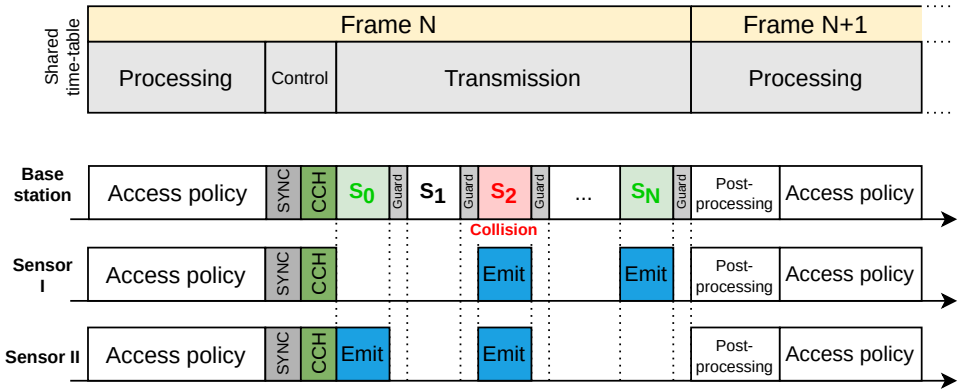

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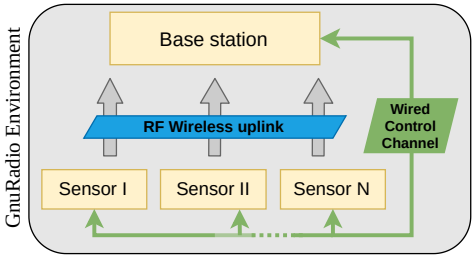
Adaptive implementation

Implement MAC layer in GNU Radio

- Time consuming;
- Unnecessarily difficulty.



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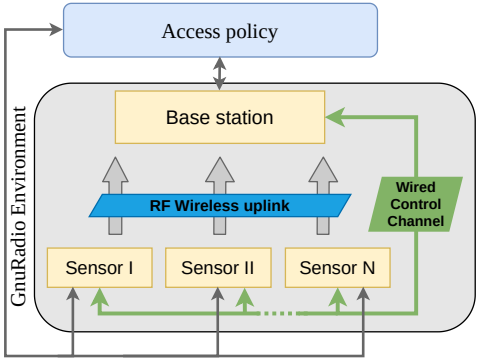

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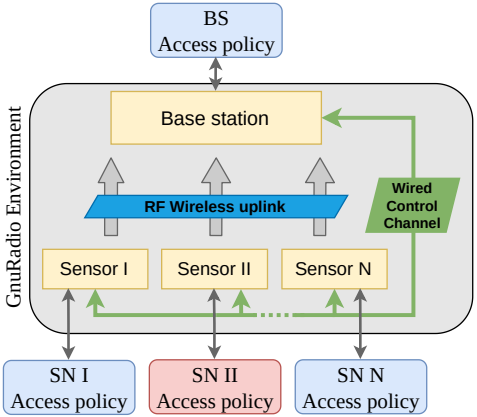

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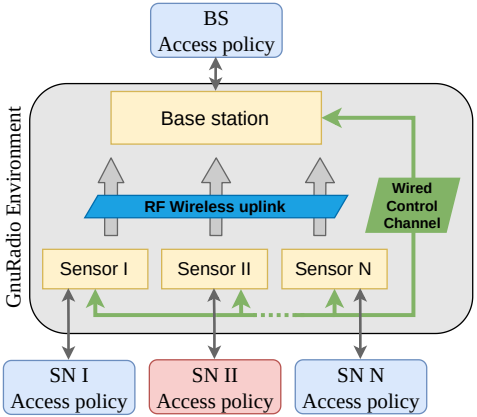

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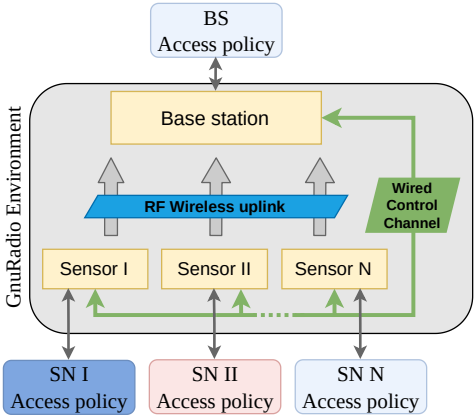

Figure: Access policy implementation

Dummy access policy

```
up = upper()

while True:
    pp = up.extract(up.recv())
    print("SN : %s, Frame : %s" % (pp["NODE"], pp["FRAME"]))

    if pp["DLCCH"] == "GR_Con_22":
        inst = up.create_SN_inst(   pp["NODE"], pp["FRAME"] +1,
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ZMQ message passing

PMT dict

Modular physical layer

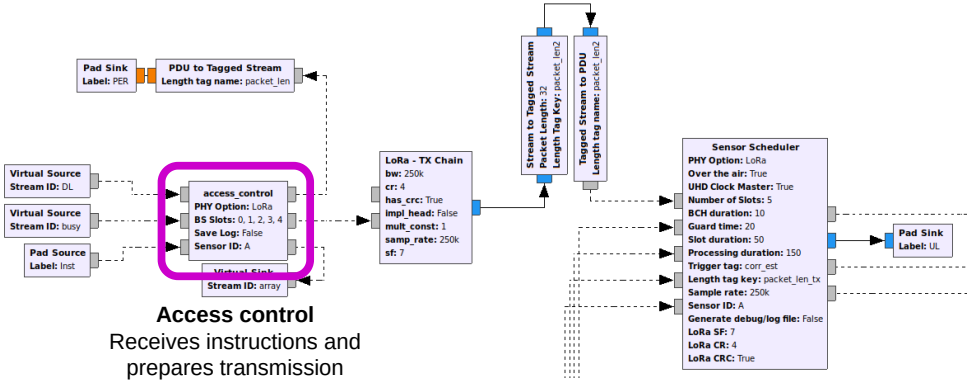
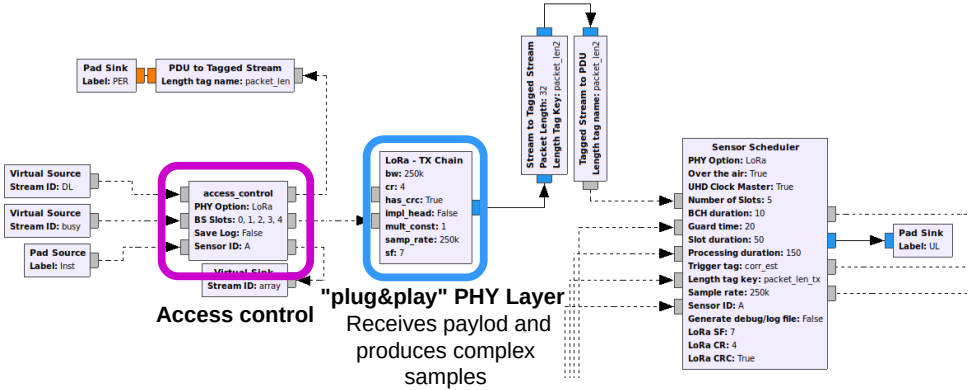


Figure: Sensor architecture

Modular physical layer



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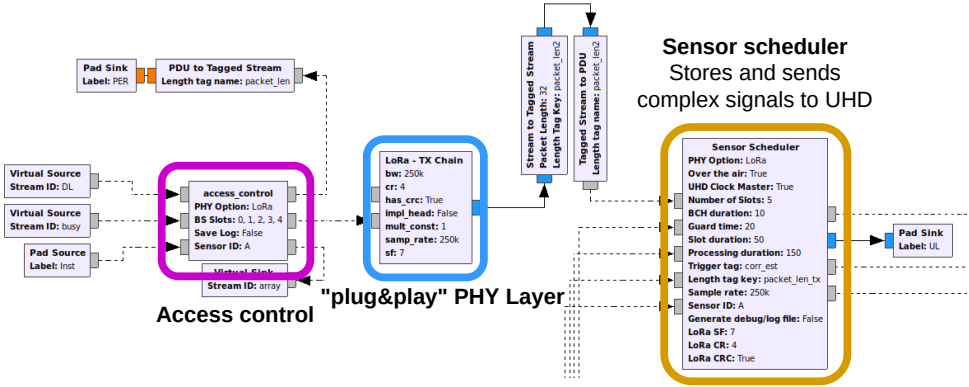

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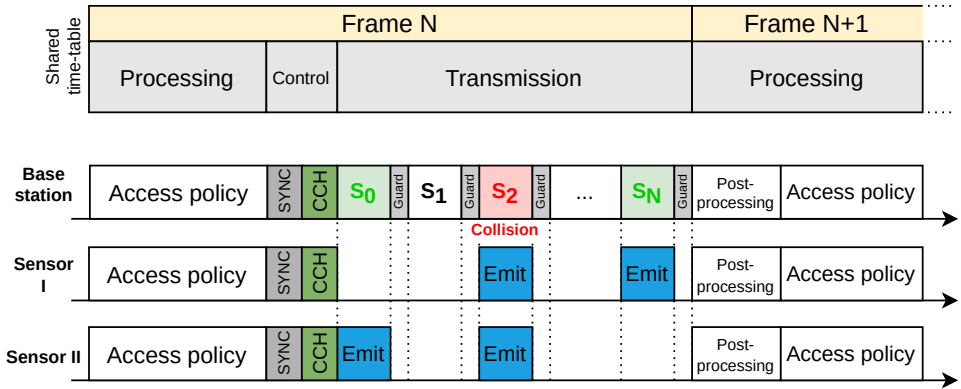

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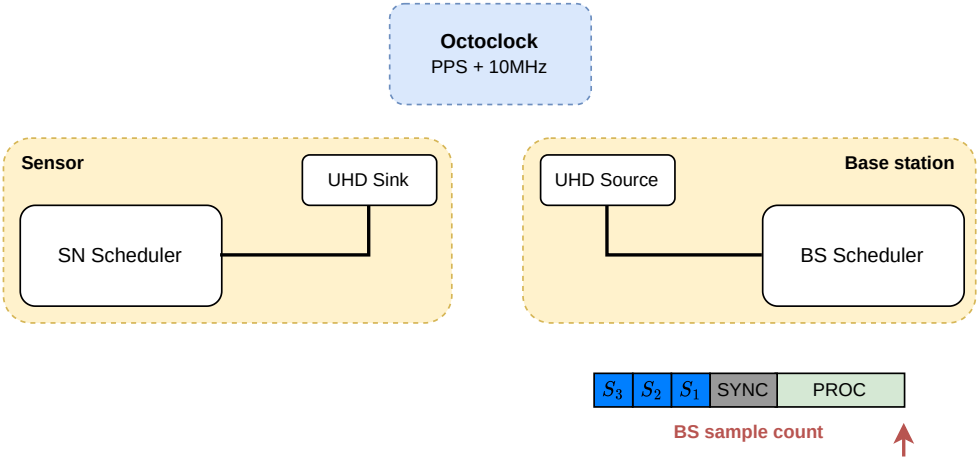

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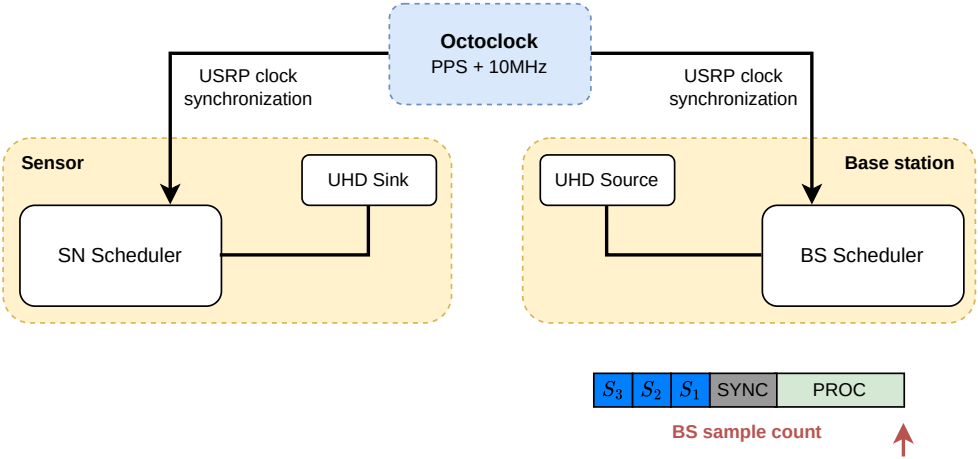

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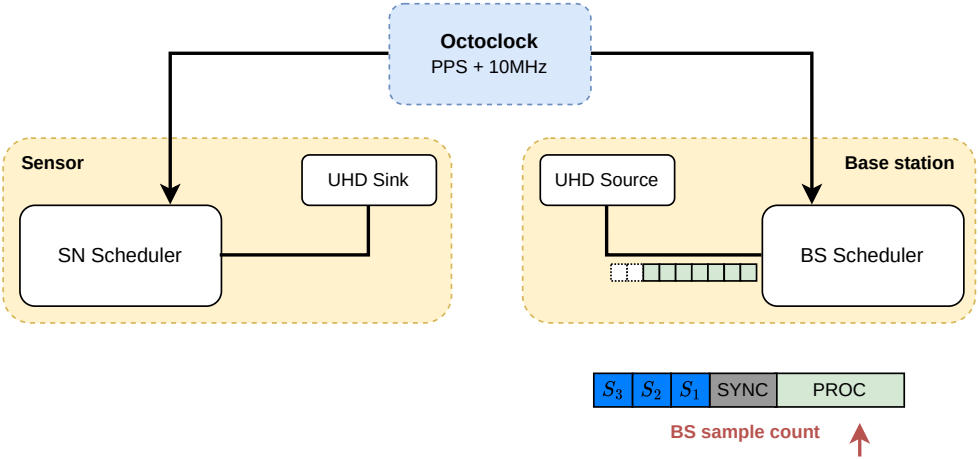

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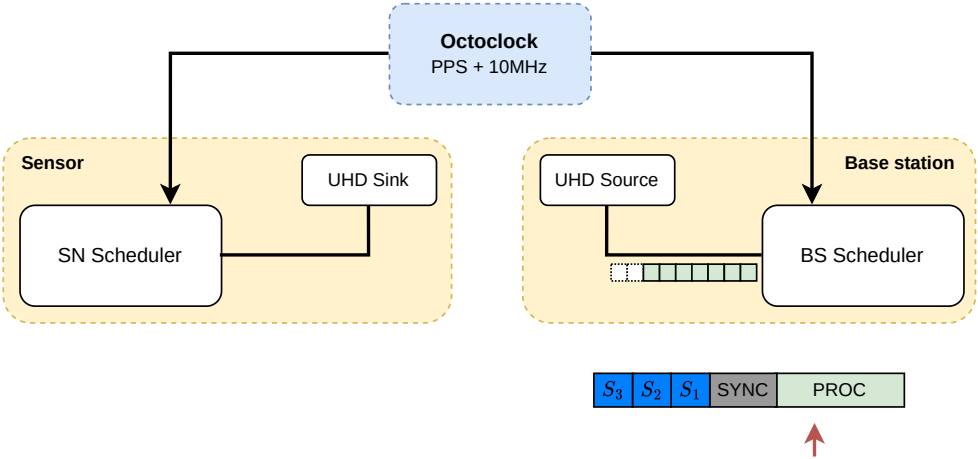

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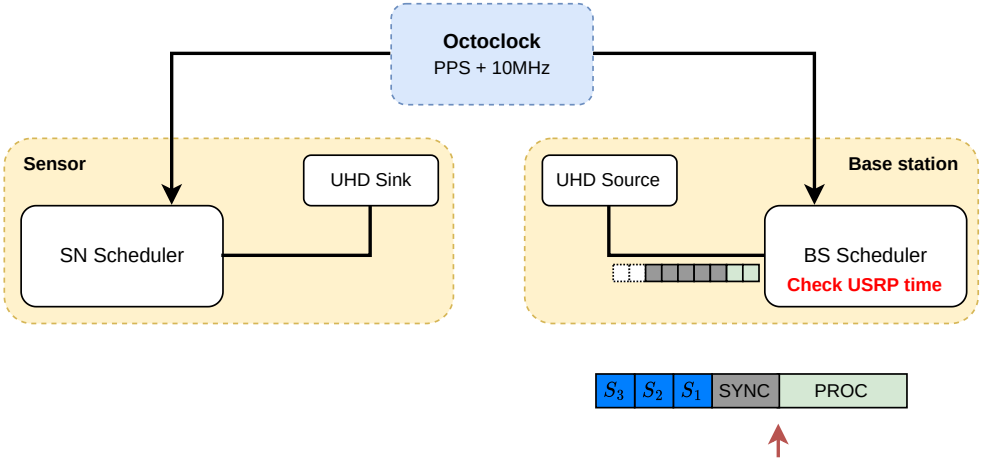

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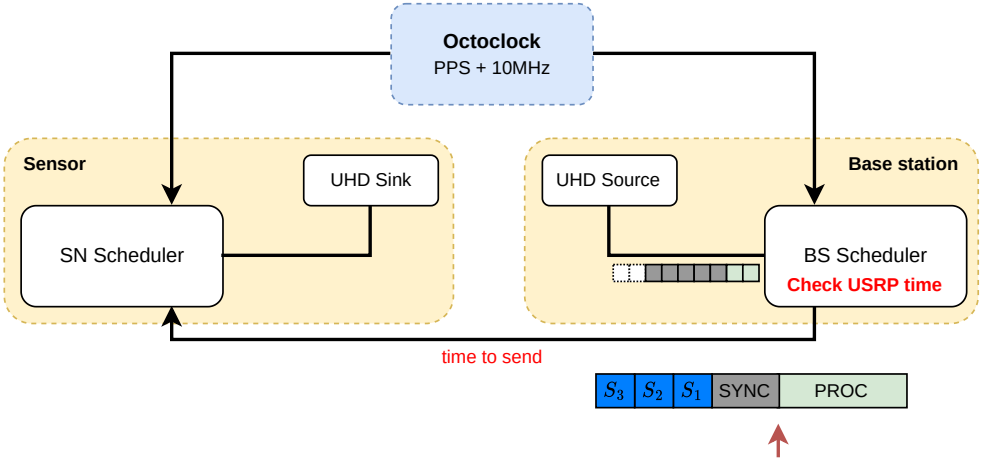

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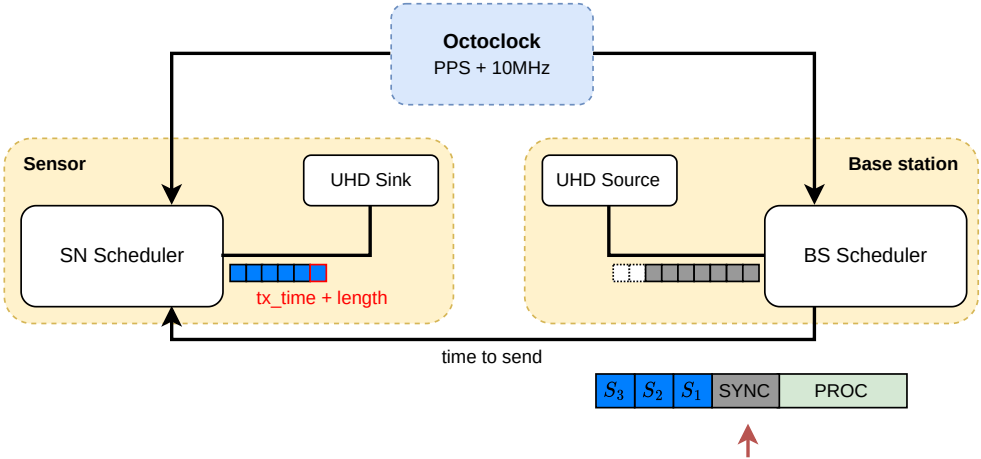

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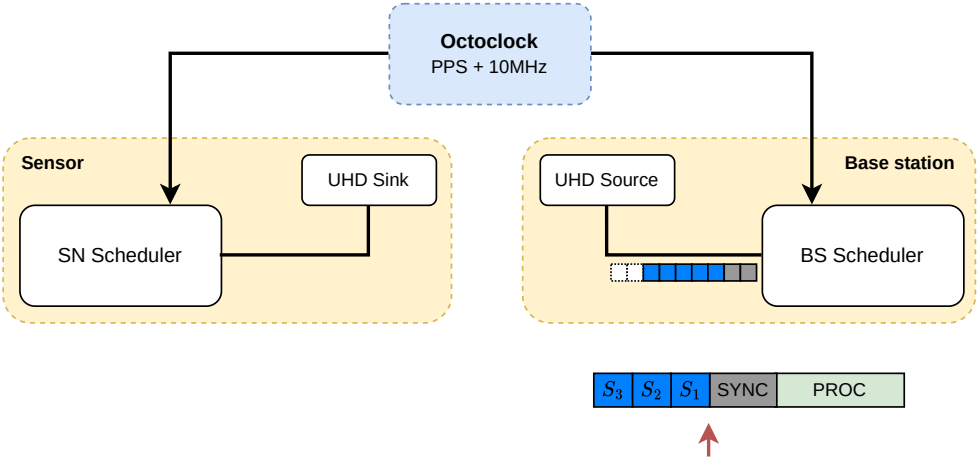

Synchronization

TX synchronization

- $\mathbf{0 \pm 150ns}$ delay for two nodes transmitting at the same time[1]

[1] Measurement made @10MHz samp_rate within FIT/CorteXlab by Cyrille Morin, Centrale Supelec, France

Synchronization

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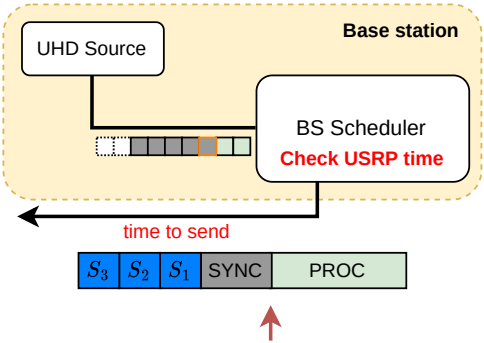
- **avg 0.7ms** delay between one node transmission and RX window



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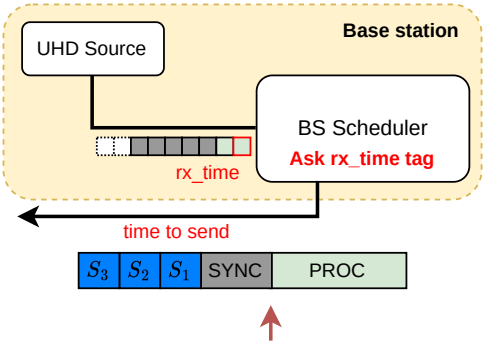

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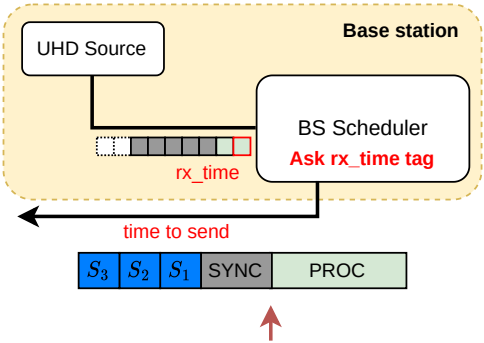
Generation of dataset



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- Development phase;
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- LoRa [2]
- Nb IoT, under development
- Yours ...

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Possibility to emulate nodes

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Tutorial

Available on the FIT/CorteXlab wiki [under development]:

- Two nodes
- Random access policies

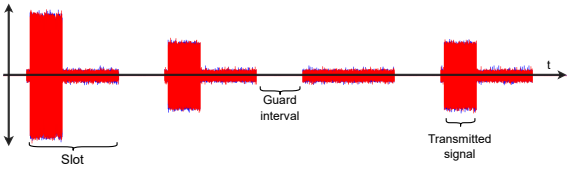

Figure: Received signal at the BS

S3-CAP tutorial : `https://wiki.cortexlab.fr/doku.php?id=ephyl_framework_v2`

S3_CAP Framework

Current and future work :

- **Nb IoT** : Finalisation of the Nb Iot PHY layer
- **RL access policies** : Apply a RL access policies method designed for LoRa system
- **Interference statistics** : Study the distribution of baseband IQ samples during collision

Thanks !

If you have any additional questions or requests, please contact us at :

amaury.paris@insa-lyon.fr

leonardo.cardoso@insa-lyon.fr

- **FIT/CortexXlab** : `http://www.cortexlab.fr/`
- **Wiki FIT/CorteXlab** : `https://wiki.cortexlab.fr/doku.php`
- **S3-CAP tutorial** : `https://wiki.cortexlab.fr/doku.php?id=ephyl_framework_v2`