EAR-IT

the sounds of smart environment

WP1 Acoustic Test bed qualification

Qualify and Benchmark Test-beds for Acoustics in Deployment of Targeted Applications

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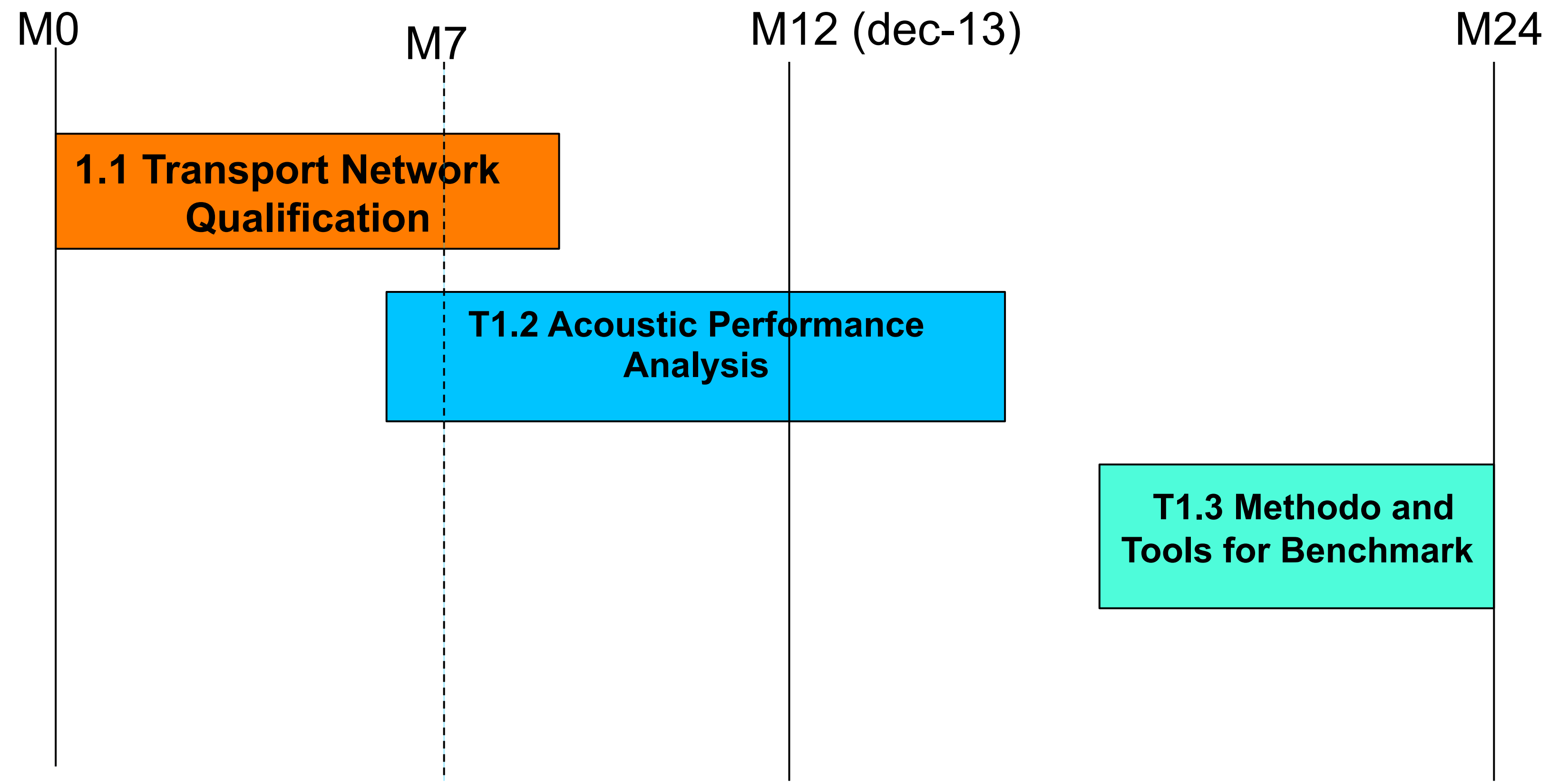
WP1 tasks


M0
M7
M12 (dec-13)
M24
1.1 Transport Network Qualification
T1.2 Acoustic Performance Analysis
T1.3 Methodo and Tools for Benchmark

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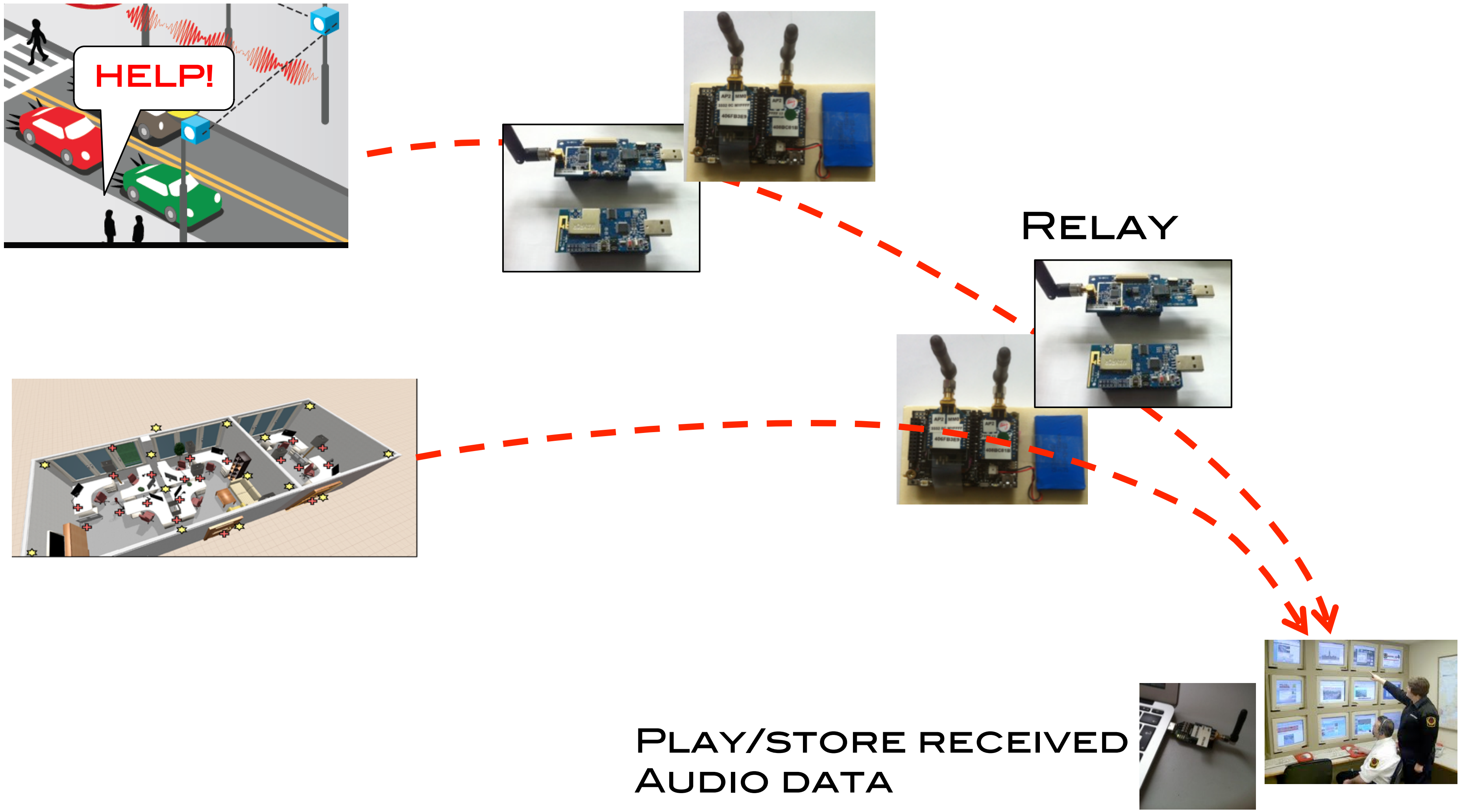
T1.2 Acoustic Performance Analysis

Methodology, lab tests and in-situ tests

T1.2

- Objectives- While network condition well established under previous task and links established to allow audio data stream, this part will investigate the minimum requirements and quality necessary for the exploitation of audio data as well as repeatability of the experiments. This will be done by specific audio measurement to qualify the environment and this will performed in close coordination with WP2 and WP3.
- Work plan- The general work plan for achieving the objectives of this task is:
  - Prepare for audio tests: Defined the condition where audio data will be collected and adapt if necessary the sensor for acoustic measurements;
  - Do audio-on-IP tests: perform test campaigns to collect audio-on-ip measurements on several different settings on the Santander and Geneva test sites. Measurement data can be on throughput, latency. Jitter, Packet loss rate, Packet loss patterns;
  - Provide overall data and analysis: provide several data and analysis to be used for benchmarking and could also lead to MOS (Mean Opinion Score).

The sounds of smart environments



Performance indicators

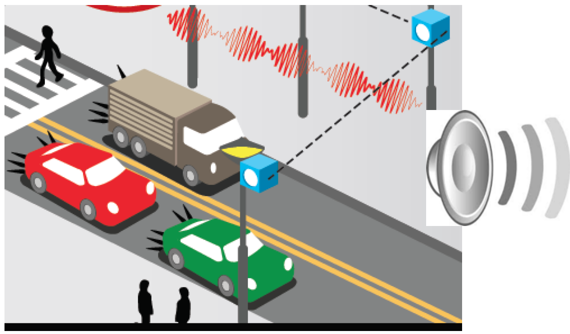
- Network performance indicators
  - 1-hop latency, relay latency, end-to-end latency
  - Packet jitter, packet loss rate
- Audio quality indicators
  - Can use Mean Opinion Score (MOS) to have a quantitative value to rank audio quality

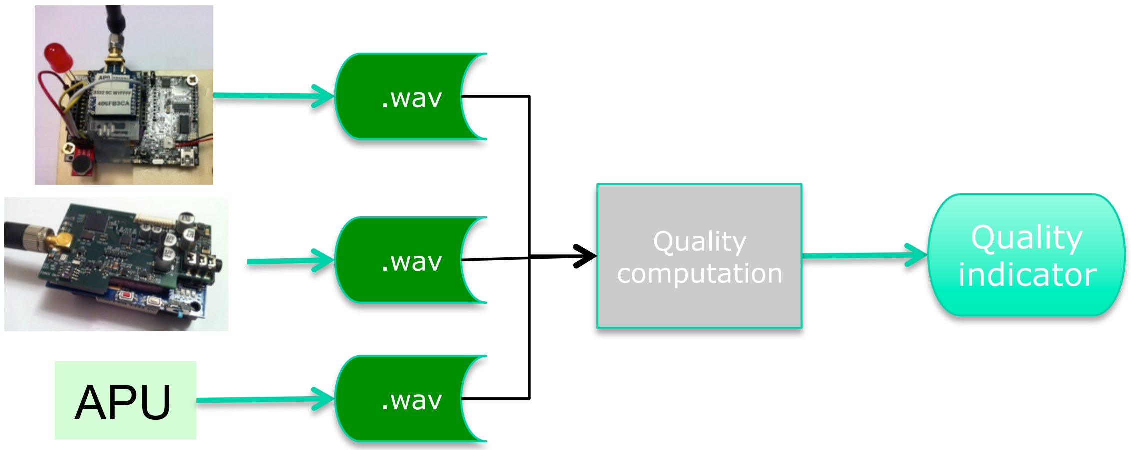
Audio test-bed description

- Refer to document
  - Audio test-bed description

Define audio reference quality

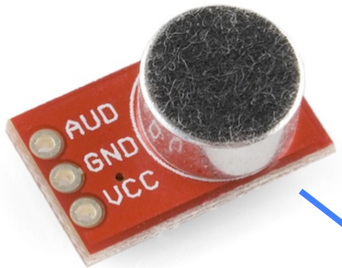
- Audio Processing Unit (APU) have better audio capture capabilities than IoT nodes
- Need to compare the quality of IoT's audio and APU's audio taken as a reference



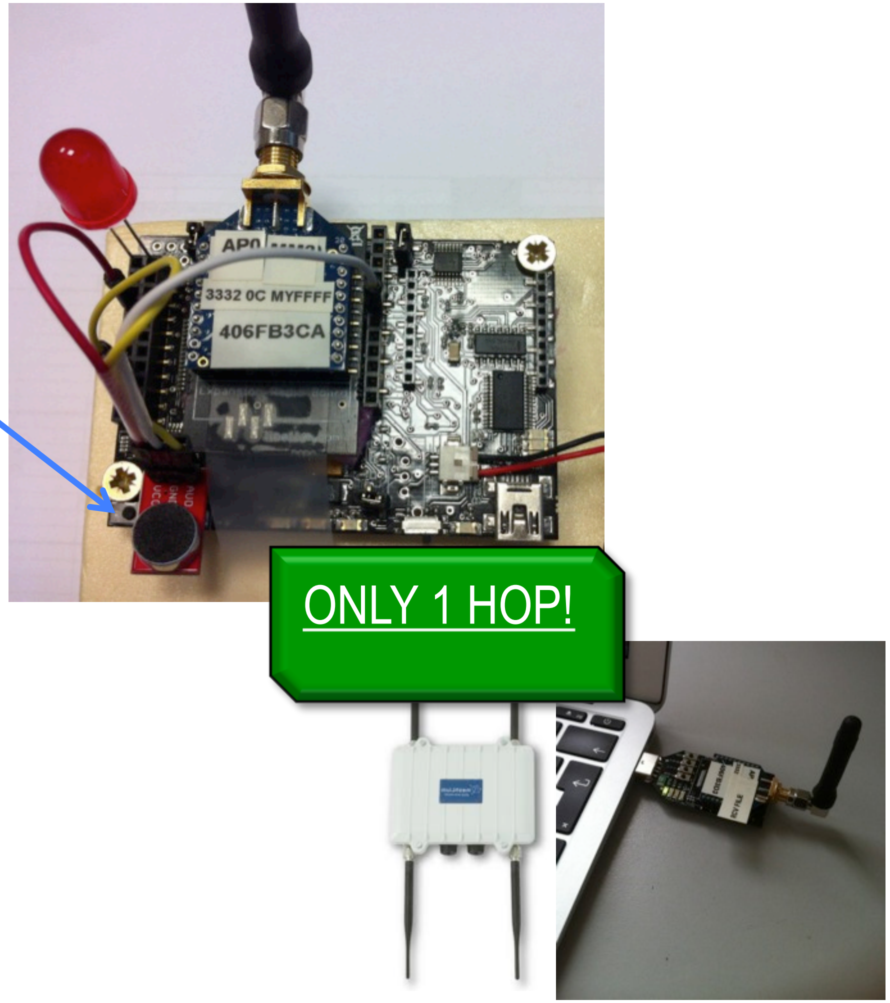


1-hop: XBee in raw mode

- Electret mic with amplifier

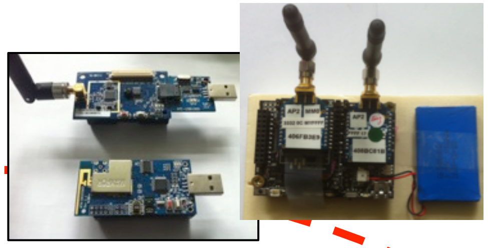


- XBee in AP0 mode (transparent mode)
- 8-bit 4Khz sampling gives 32000bps
- 8Khz sampling gives 64000bps, requires custom API

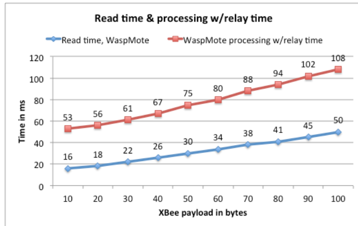


Multi-hop audio constraints

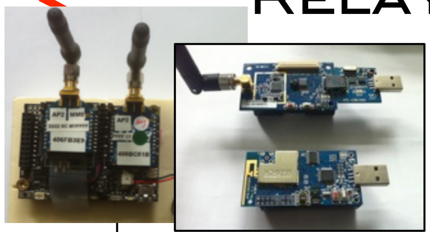
Source

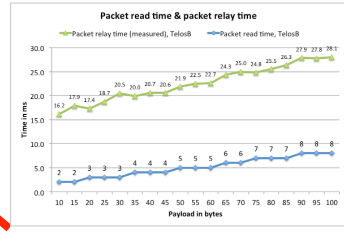


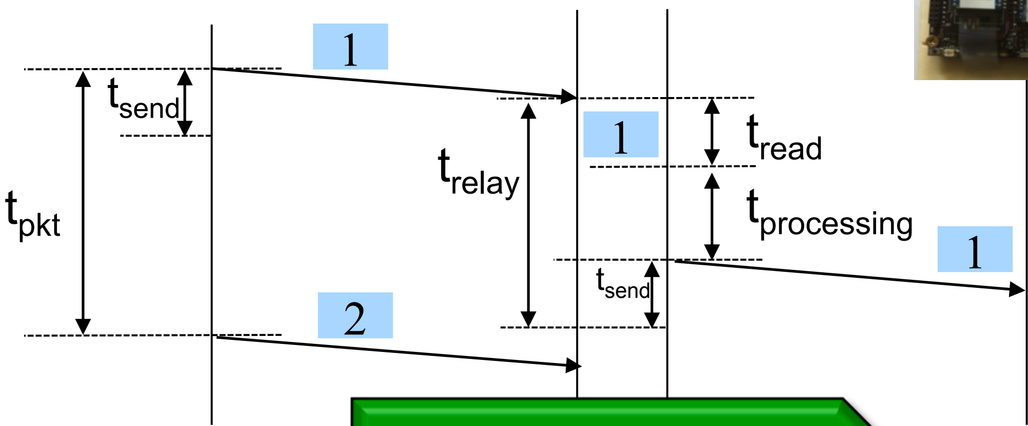
Relay



Relay





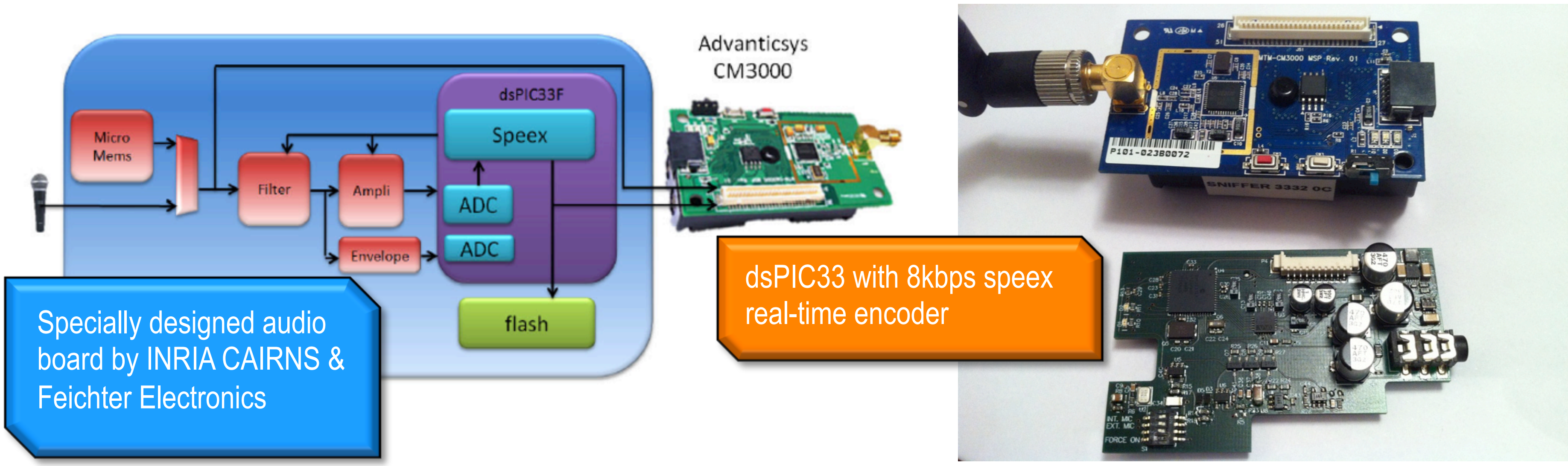


Intermediate nodes can have limited performances

Play received file

Multi-hop audio solution

- Use dedicated audio board for sampling/storing/encoding at 8kbps



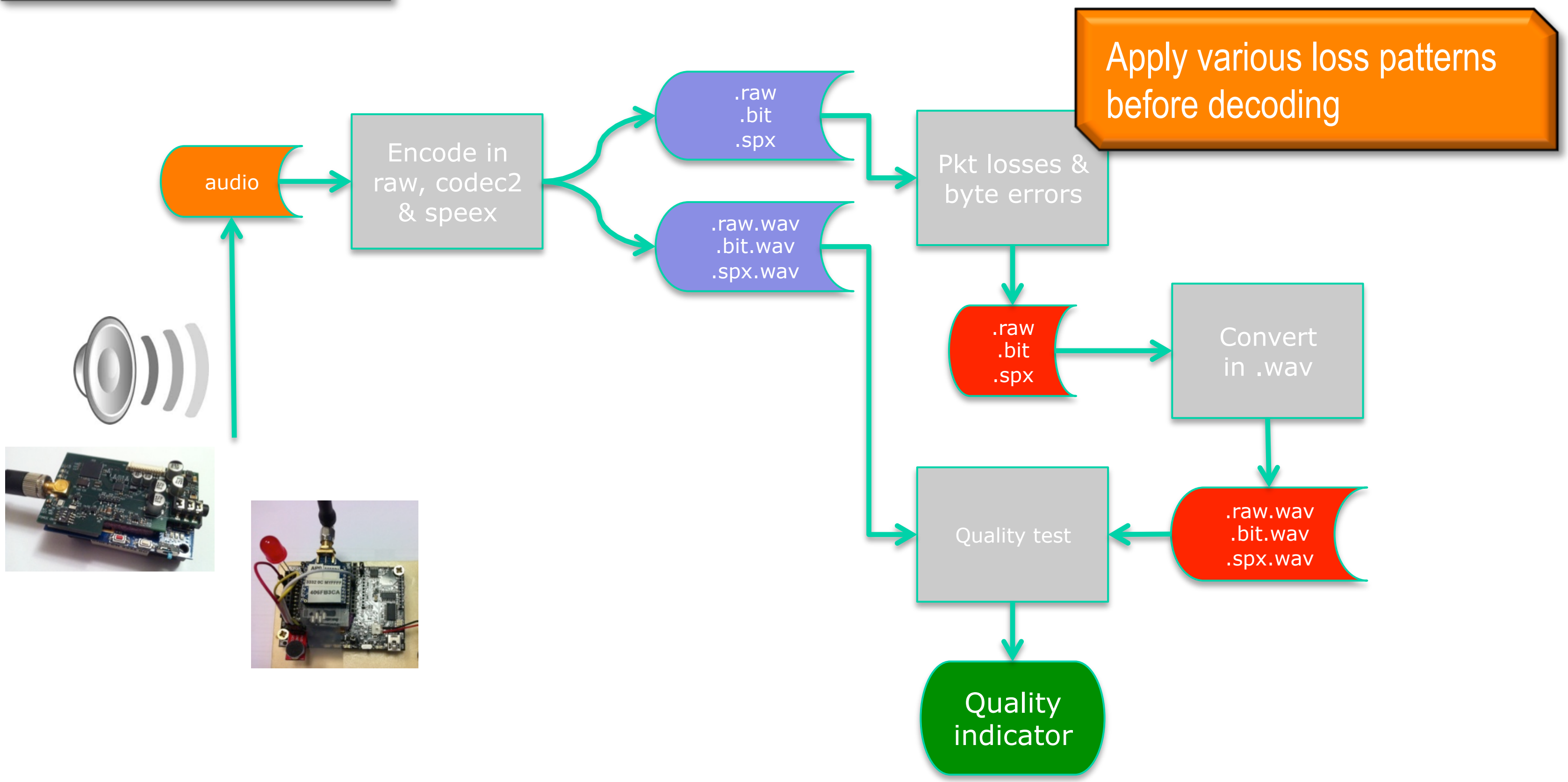
- Allows for multi-hop, encoded audio streaming scenarios

Benchmark methodology

1. Determine sensitivity of codec against packet losses, with various packet size, lab tests
   - audio benchmarking, apply controlled packet error rates
   - MOS-LQO computation
2. Determine channel condition in selected areas, in-situ tests
   - Synthetic workload to determine packet loss rates
3. Determine latencies and jitter in multi-hop scenario, lab tests & in-situ tests
   - Controlled transmission of packetized/encoded audio
   - Measure latencies and jitter at intermediate nodes

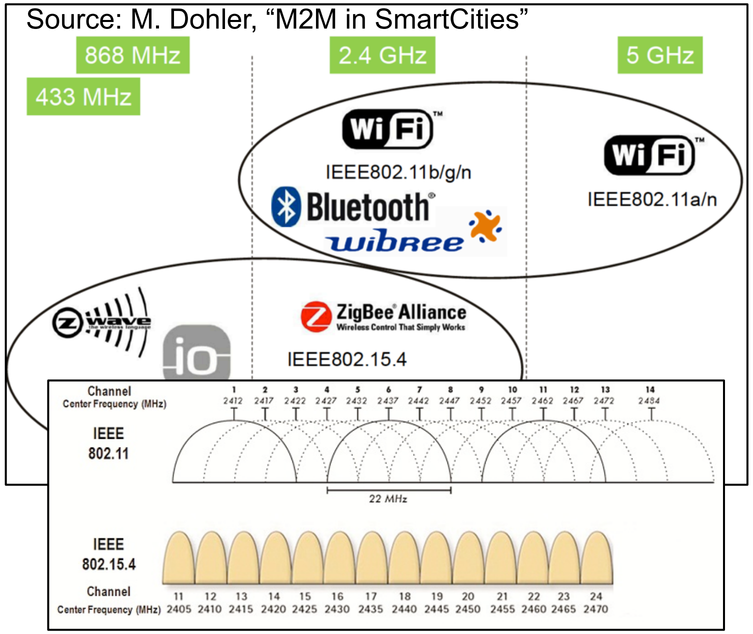
Sensitivity of codecs

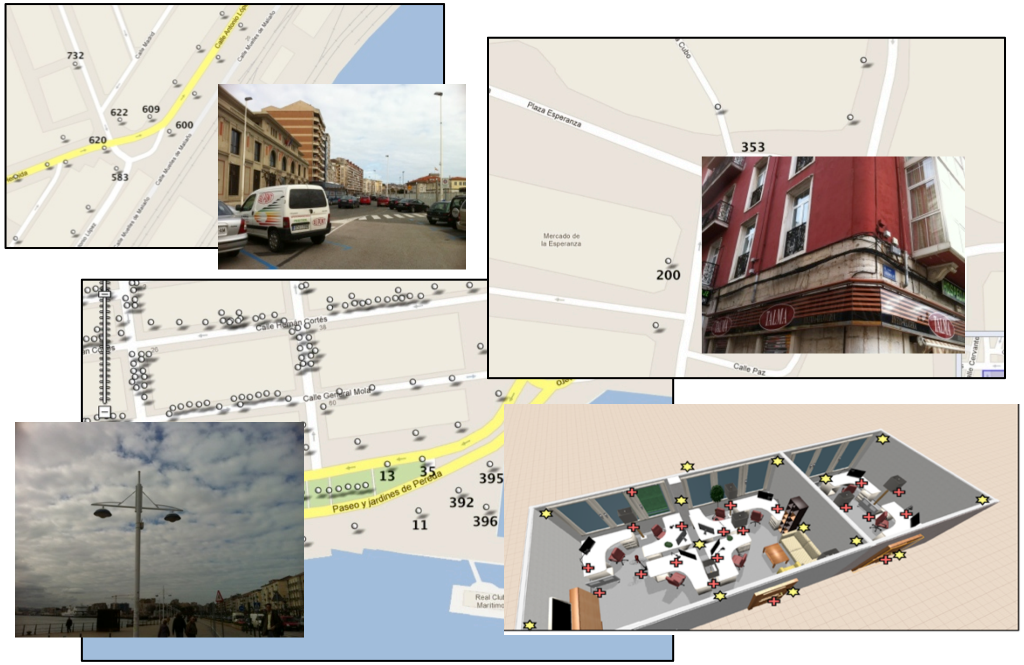
LAB TESTS



Channel condition in selected areas

IN-SITU TESTS





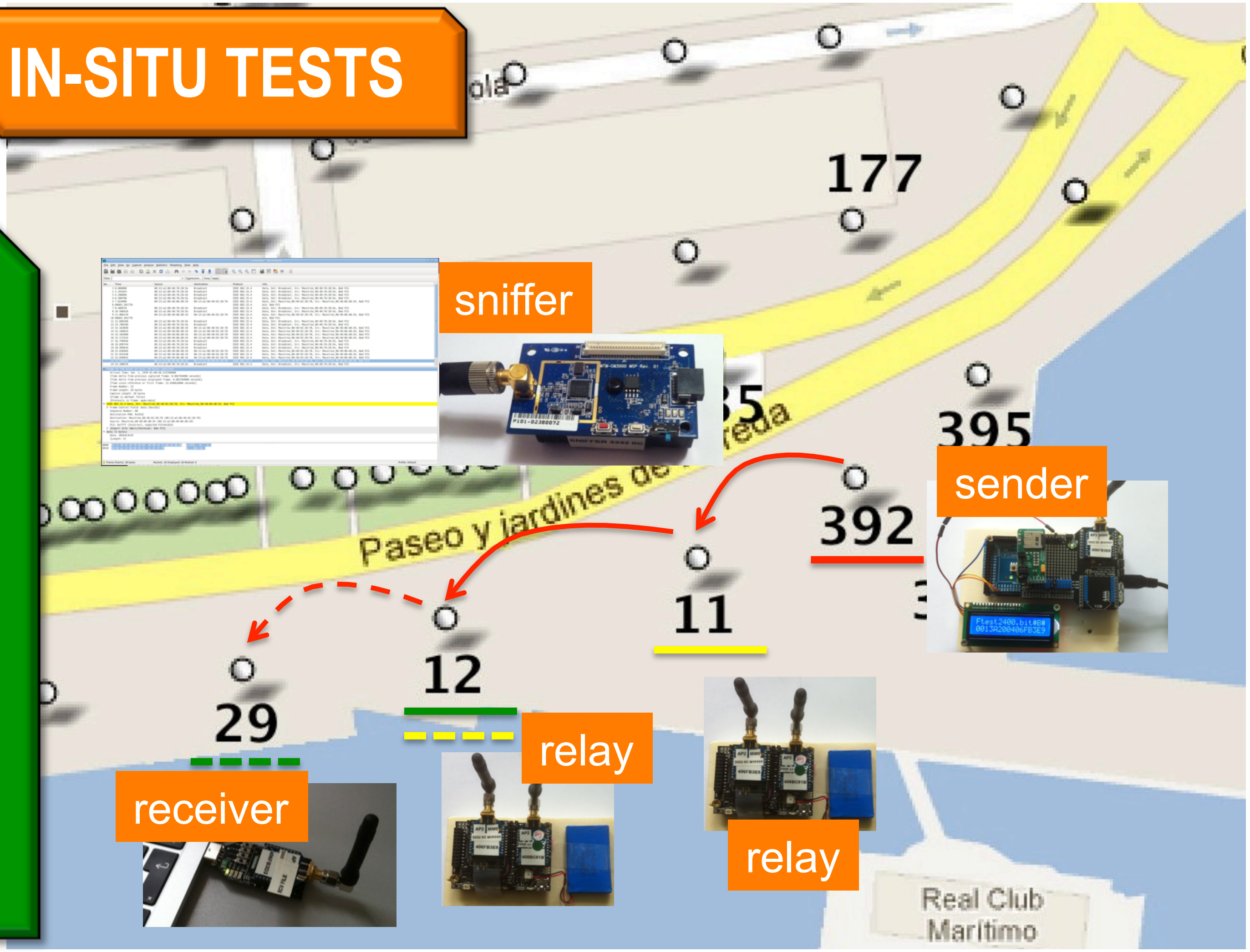
- Use representive locations in Santander & Geneva buildings
- Deploy IoT nodes traffic generators & sniffers
- Vary 802.15.4 channel and determine packet loss rates at various workload

Latency and jitter in multi-hop

LAB TESTS **IN-SITU TESTS**

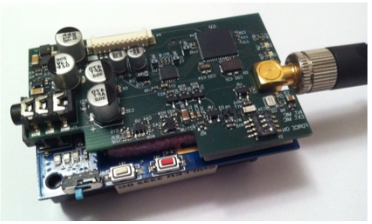
Sniffer node will capture all frames in order to measure inter-node latencies

Jitter will be measured at intermediate node as inter-packet time in known at sender side



1-hop test-bed w/audio board

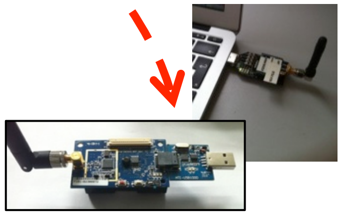
0x0090



SPEEX AUDIO ENCODING
8KBPS

```
A1/2/3/4 aggregate audio frames
D0100 set the 16-bit dest. mac addr
C0/1 power off/on the audio board
```

0x0100

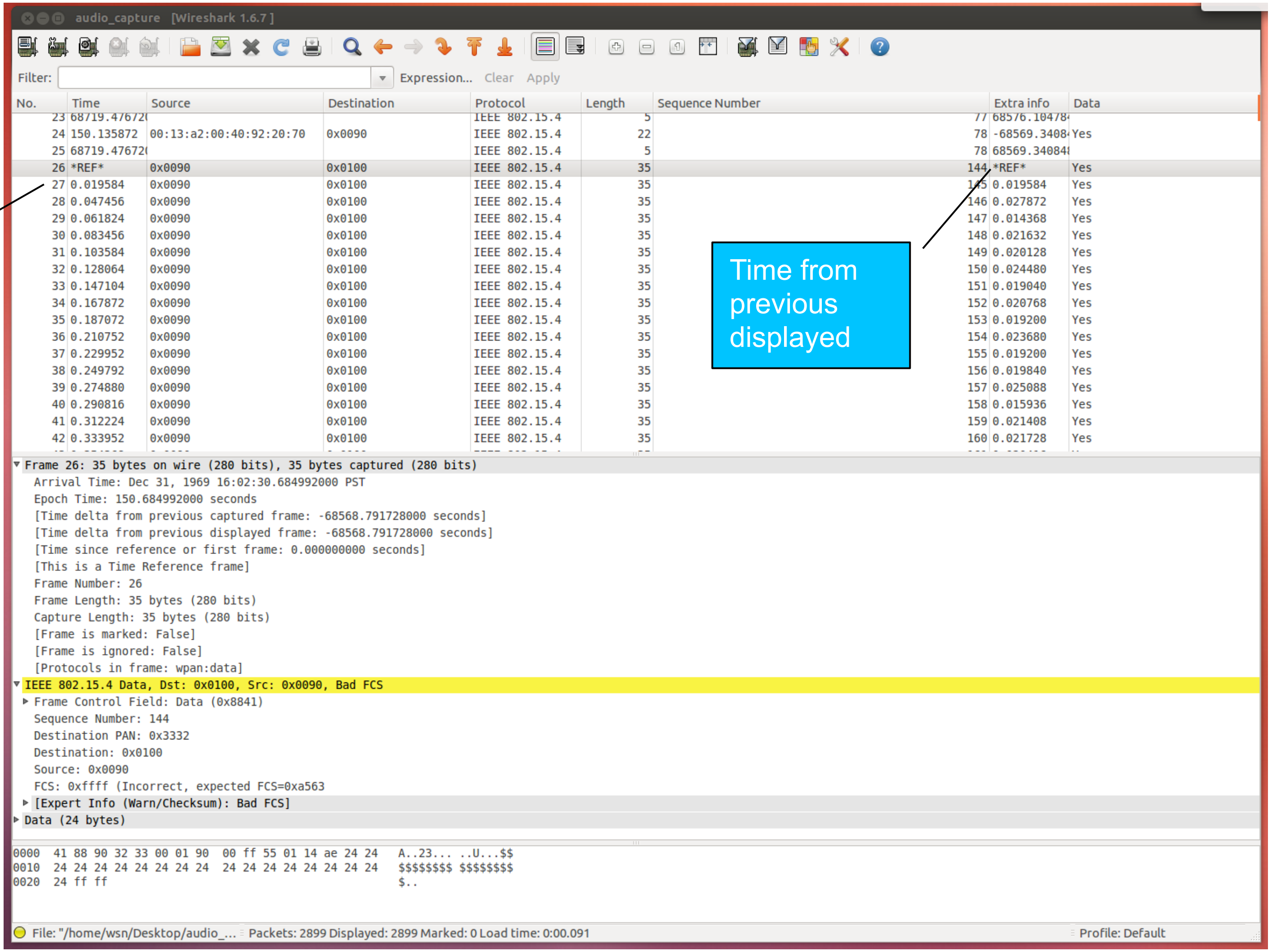


```
python 115200SerialToStdout.py | ./speex_sampledec_wframing essai.raw |
play --buffer 100 -t raw -r 8000 -s -2 -
```

DECODE & PLAY
RECEIVED AUDIO

Example: latency 1-hop

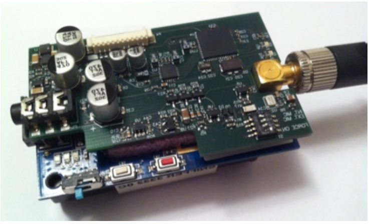
Time from reference time



Time from previous displayed

2-hop test-bed w/audio board

0x0090

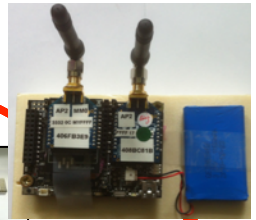


SPEEX AUDIO ENCODING
8KBPS

A1/2/3/4/6 aggregate audio frames
D0200 set the 16-bit dest. mac addr
C0/1 power off/on the audio board

R0/1 enable/disable relay mode
D0100 set the 16-bit dest. mac addr

RELAY



0x0200

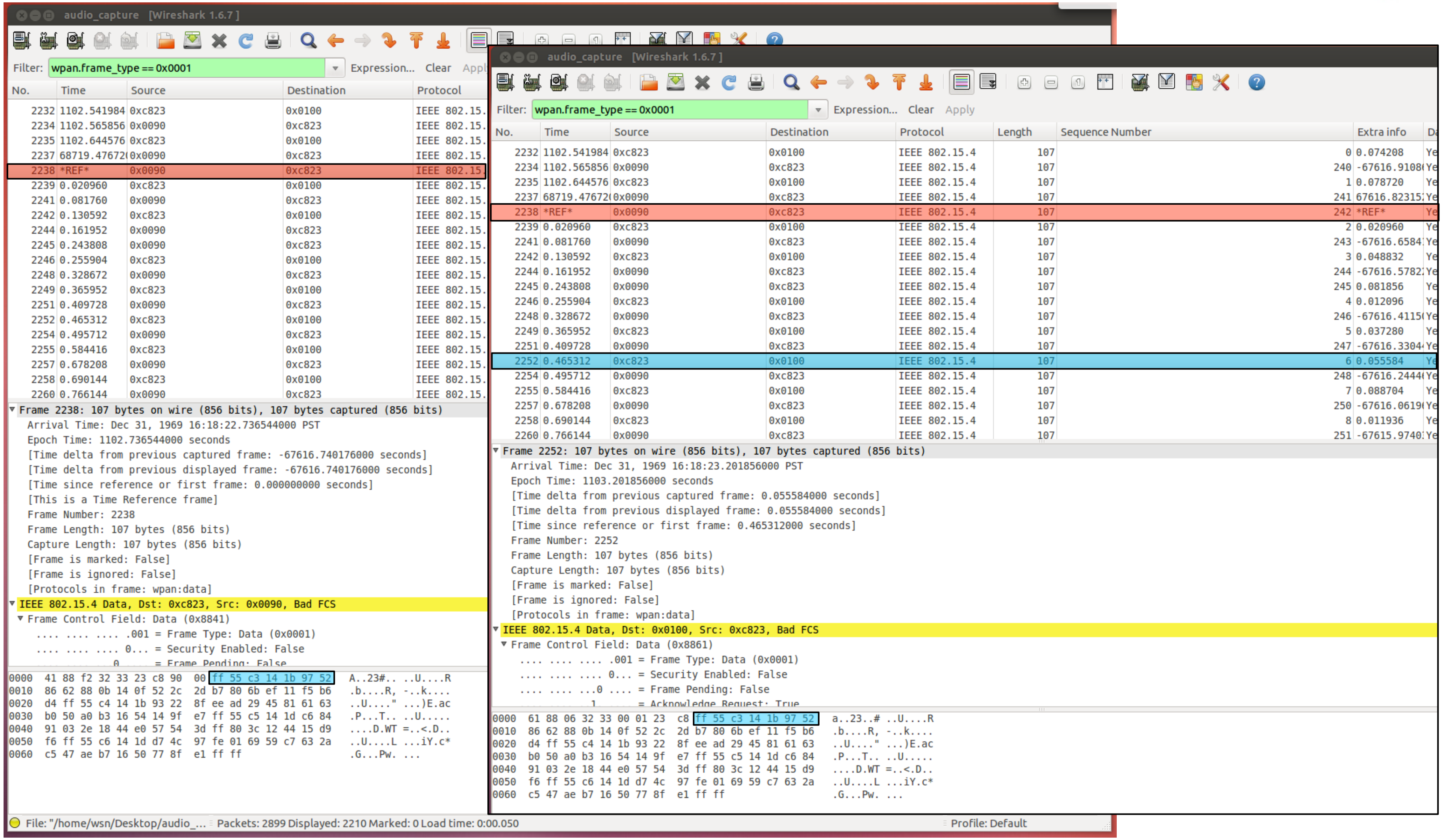
0xC823

0x0100

```
python 115200SerialToStdout.py | ./speex_sampledec_wframing essai.raw |
play --buffer 100 -t raw -r 8000 -s -2 -
```

DECODE & PLAY
RECEIVED AUDIO

Example: latency 2-hop



Audio quality: PESQ & MOS (1)

- ITU-T P.862 Perceptual evaluation of speech quality (PESQ): An objective method for end-to-end speech quality assessment of narrow-band telephone networks and speech codecs.
- Download software at : https://www.itu.int/rec/dologin_pub.asp?lang=e&id=T-REC-P.862-200511-I!Amd2!SOFT-ZST-E&type=items

Audio quality: PESQ & MOS (2)

- We can use ITU-T PESQ tool to determine the MOS value for loss-free encoded audio (codec2, speex). MOS-LQO values greater than 2.6 are considered quite acceptable
- 5=Excellent, 4=Good, 3=Fair, 2=Poor, 1=Bad

REFERENCE	DEGRADED	PESQMOS	MOSLQO	SAMPLE_FREQ
test.wav	test.wav	4.500	4.549	8000
test.wav	test2150.spx.wav	2.757	2.472	8000
test.wav	test5950.spx.wav	3.428	3.454	8000
test.wav	test8000.spx.wav	3.652	3.757	8000
test.wav	test11000.spx.wav	3.941	4.093	8000
test.wav	test13000.spx.wav	3.941	4.093	8000
test.wav	test15000.spx.wav	4.085	4.235	8000
test.wav	test1600.bit.raw.wav	2.648	2.323	8000
test.wav	test1400.bit.raw.wav	2.625	2.293	8000
test.wav	test2400.bit.raw.wav	2.768	2.487	8000
test.wav	test3200.bit.raw.wav	2.801	2.533	8000

PESQ & MOS of iThing'13 results

REFERENCE	DEGRADED	PESQMOS	MOSLQO	SAMPLE_FREQ
test2400.bit.raw.wav	test2400-44-105-6L-F77.bit.raw.wav	2.752	2.465	8000
test2400.bit.raw.wav	test2400-44-110-0L.bit.raw.wav	4.500	4.549	8000
test2400.bit.raw.wav	test2400-54-110-5L-F77.bit.raw.wav	2.725	2.427	8000
test2400.bit.raw.wav	test2400-54-120-2L-F77.bit.raw.wav	3.239	3.178	8000
test2400.bit.raw.wav	test2400-64-120-5L-F77.bit.raw.wav	2.737	2.444	8000
test2400.bit.raw.wav	test2400-64-125-2L-F77.bit.raw.wav	3.689	3.804	8000
test2400.bit.raw.wav	test2400.bit.raw.wav	4.500	4.549	8000

test.wav	test2400-44-105-6L-F77.bit.raw.wav	2.600	2.260	8000
test.wav	test2400-44-110-0L.bit.raw.wav	2.768	2.487	8000
test.wav	test2400-54-110-5L-F77.bit.raw.wav	2.310	1.919	8000
test.wav	test2400-54-120-2L-F77.bit.raw.wav	2.648	2.323	8000
test.wav	test2400-64-120-5L-F77.bit.raw.wav	2.307	1.916	8000
test.wav	test2400-64-125-2L-F77.bit.raw.wav	2.679	2.365	8000
test.wav	test2400.bit.raw.wav	2.768	2.487	8000
test.wav	test.wav	4.500	4.549	8000