EAR-IT *the sounds of smart environment*

WP1 Acoustic Test bed Qualification

Benchmarking procedure for other test-beds

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SEVENTH FRAMEWORK PROGRAMME

UNINOVA Instituto de Desenvolvimento de Novas Tecnologias Fraunhofer IDMT UC UNIVERSIDAD DE CANTABRIA MANDAT INTERNATIONAL CDT SmartSensingStars

Objectives of test-bed benchmarking

- Determine whether a given test-bed is capable of providing the minimum requirement for supporting audio traffic
  - Packet loss rate
  - Relaying capability
- Typical 1-hop packet loss rate need to be measured
- Performances of relay nodes need to be benchmarked for multi-hop audio
- EAR-IT support
  - Audio source nodes are provided
  - Source code of packet sniffer is available
  - Analysis script and Excel template are provided

Outline

Audio source hardware

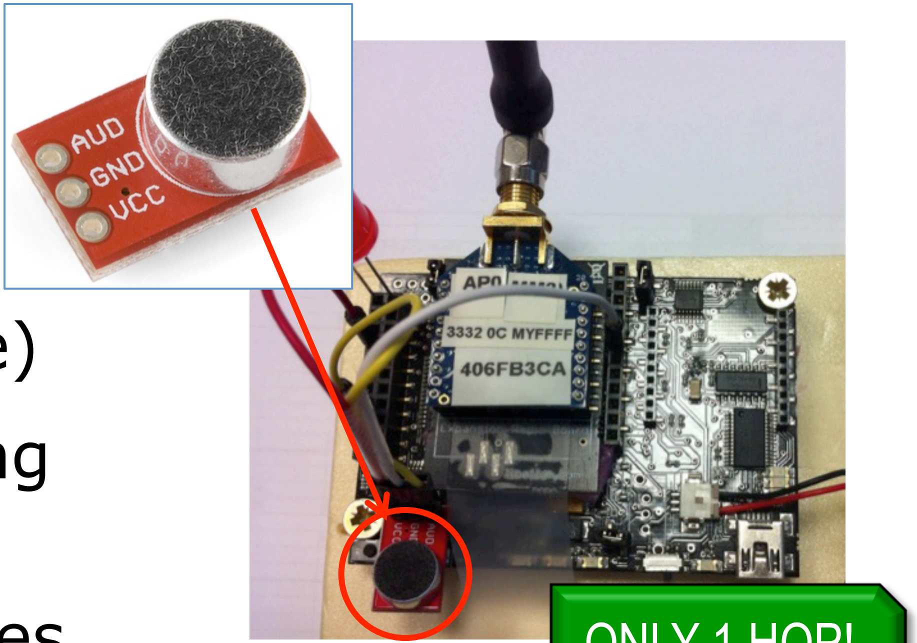
Existing relay nodes and their performances

Procedure & tools for benchmarking a new test-bed

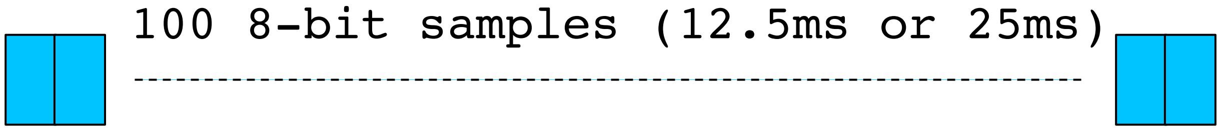
Audio source hardware

Audio source #1: WaspMote & 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

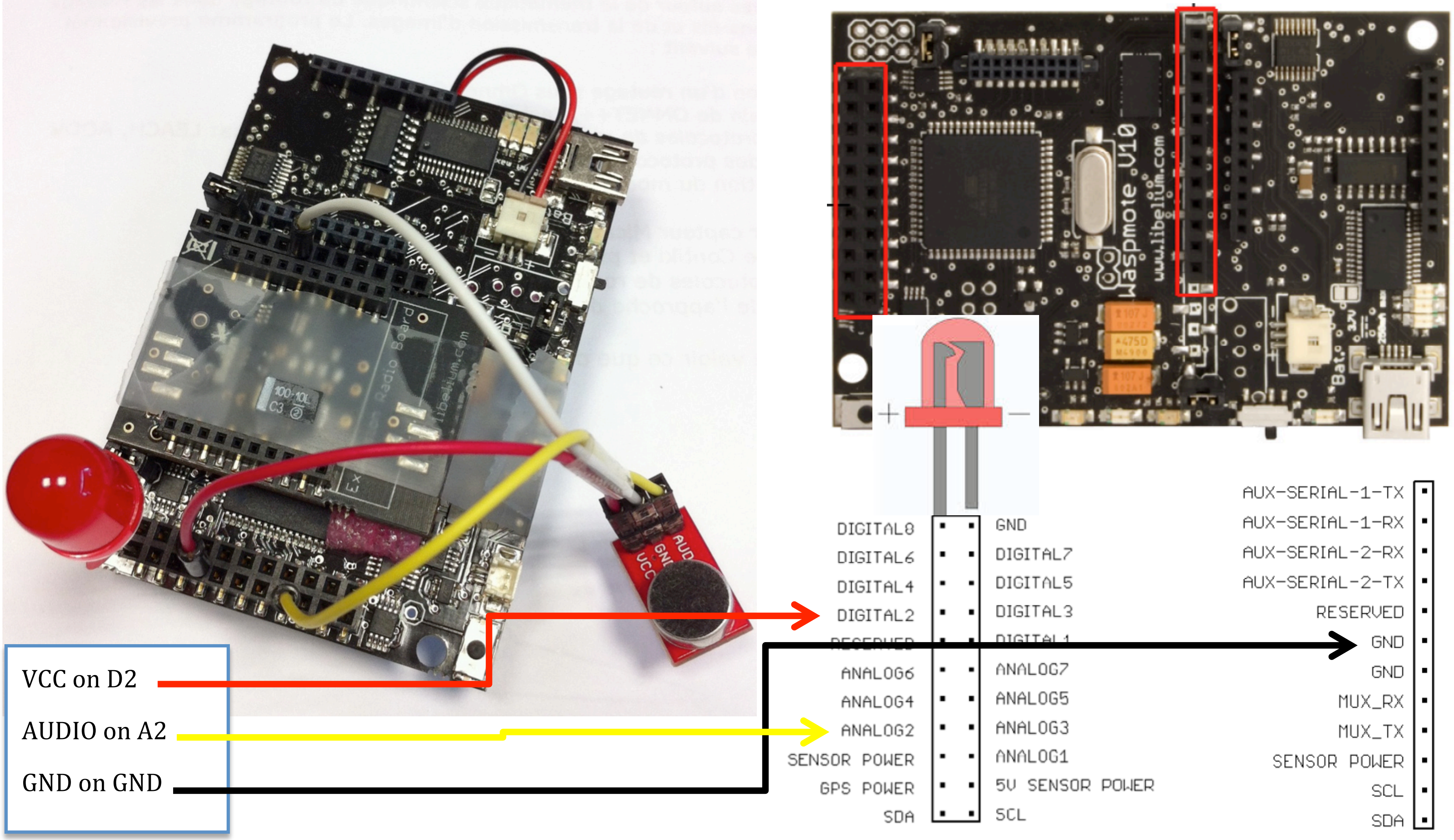


ONLY 1 HOP!



100 8-bit samples (12.5ms or 25ms)

WaspMote: details of pin connection



VCC on D2

AUDIO on A2

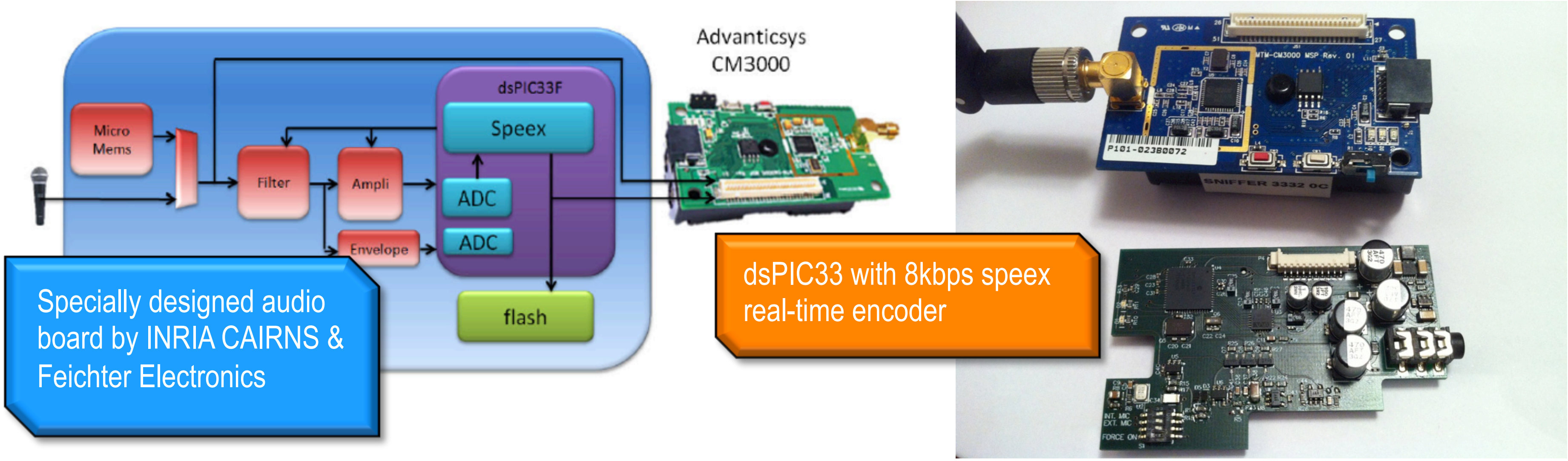
GND on GND

DIGITAL8	GND
DIGITAL6	DIGITAL7
DIGITAL4	DIGITAL5
DIGITAL2	DIGITAL3
RESERVED	DIGITAL1
ANALOG6	ANALOG7
ANALOG4	ANALOG5
ANALOG2	ANALOG3
SENSOR POWER	ANALOG1
GPS POWER	5V SENSOR POWER
SDA	SCL

AUX-SERIAL-1-TX
AUX-SERIAL-1-RX
AUX-SERIAL-2-RX
AUX-SERIAL-2-TX
RESERVED
GND
GND
MUX_RX
MUX_TX
SENSOR POWER
SCL
SDA

Audio source #2:
TelosB & dedicated audio board

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

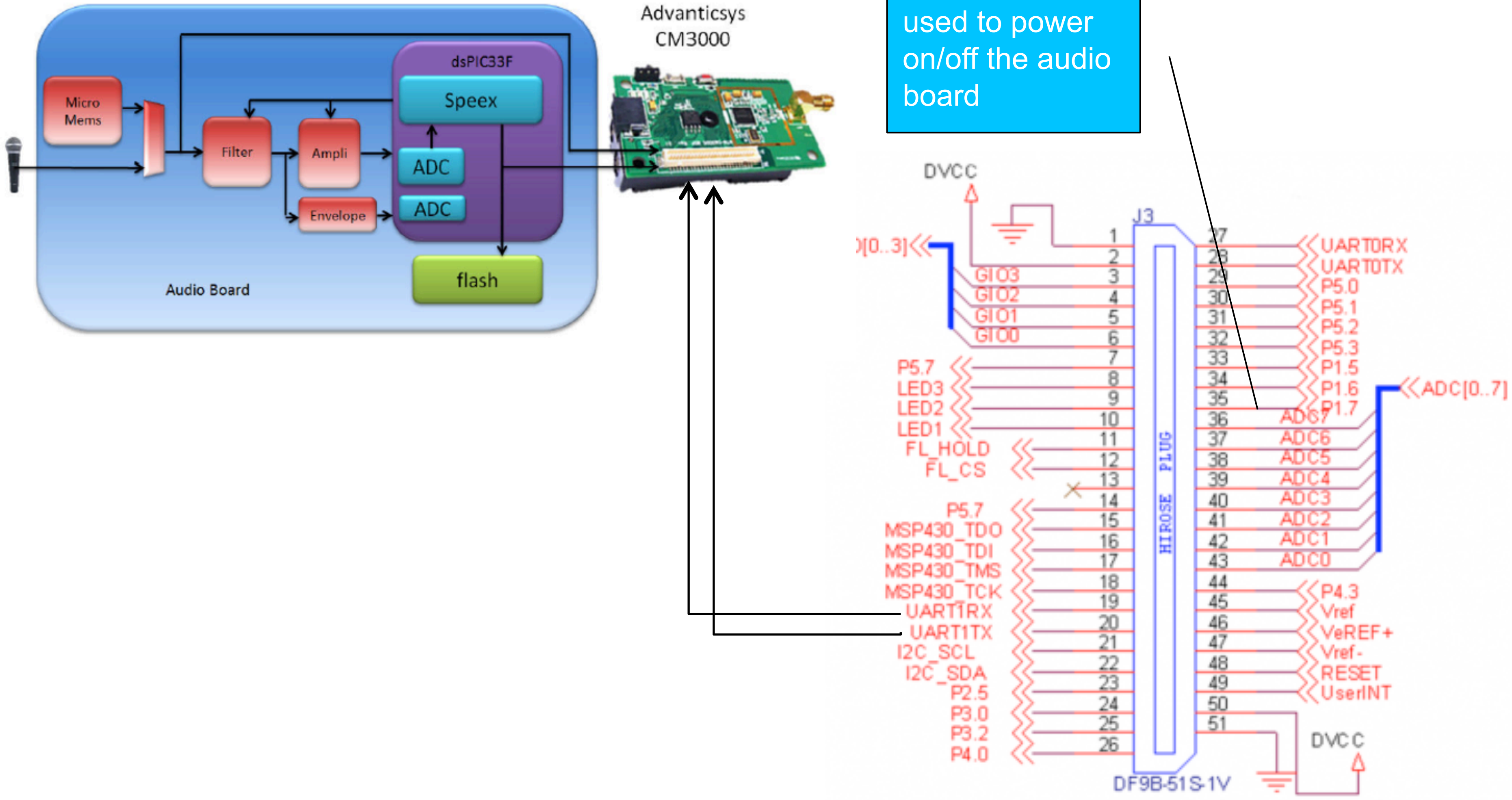


Specially designed audio board by INRIA CAIRNS & Feichter Electronics

dsPIC33 with 8kbps speex real-time encoder

- Allows for multi-hop, encoded audio streaming scenarios

TelosB:
details of pin connection

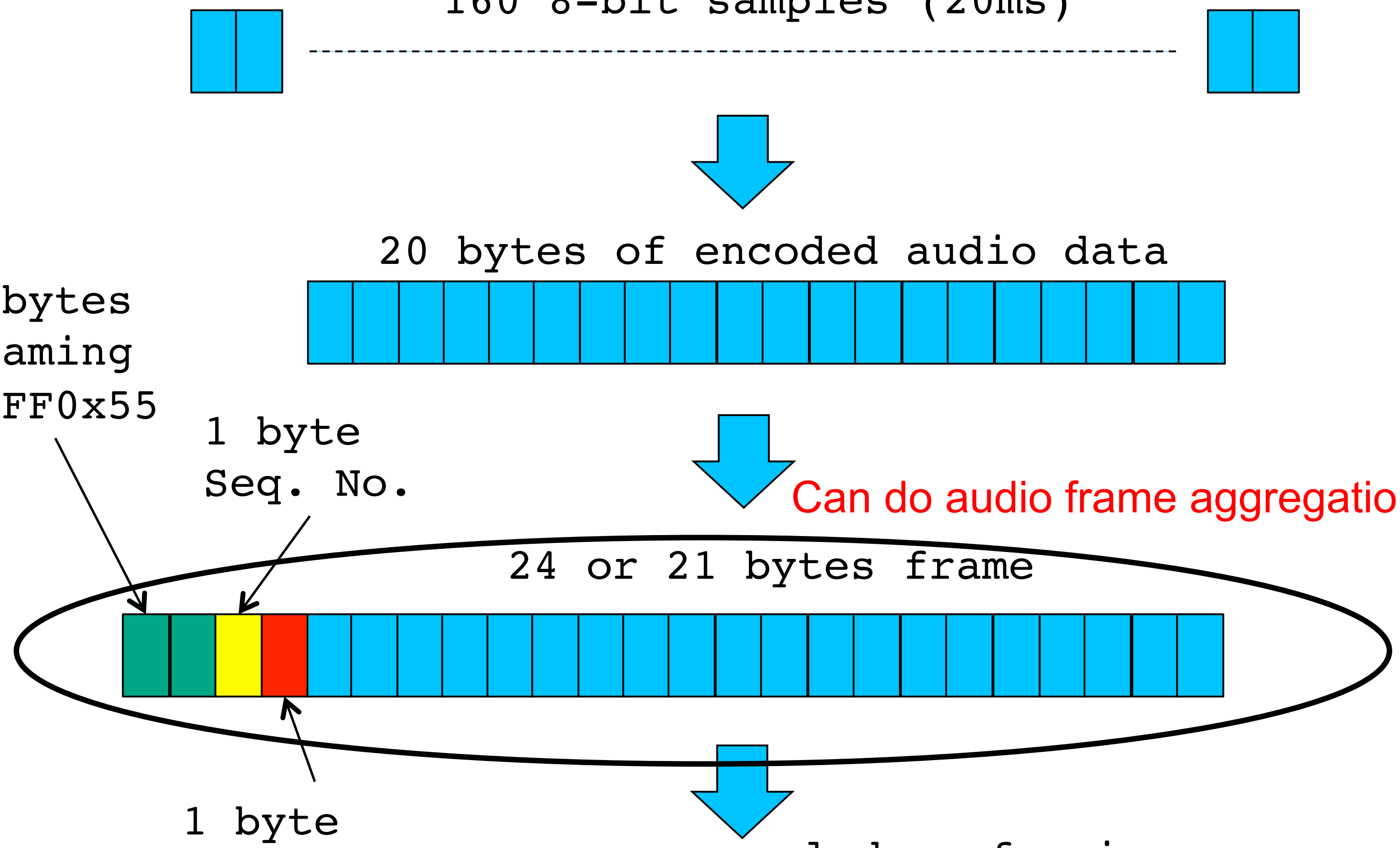


P1.7 can be used to power on/off the audio board

TelosB & audio board

- The audio board captures 160 bytes (20ms) of raw audio and uses speex codec at 8kbps to produce 20 bytes to encoded audio data
- It sends the encoded audio data through an UART line to the host micro-controller
- The host micro-controller receives the encoded data and sends them wirelessly to the next hop
- The last hop is a base station that will forward the encoded audio into a speex audio decoder
- Output of the speex audio decoder is in raw format that can be feed into a player (`play`)

speex at 8kbps



160 8-bit samples (20ms)

20 bytes of encoded audio data

2 bytes framing 0xFF0x55

1 byte Seq. No.

Can do audio frame aggregation: A1, A2, …

24 or 21 bytes frame

1 byte frame size

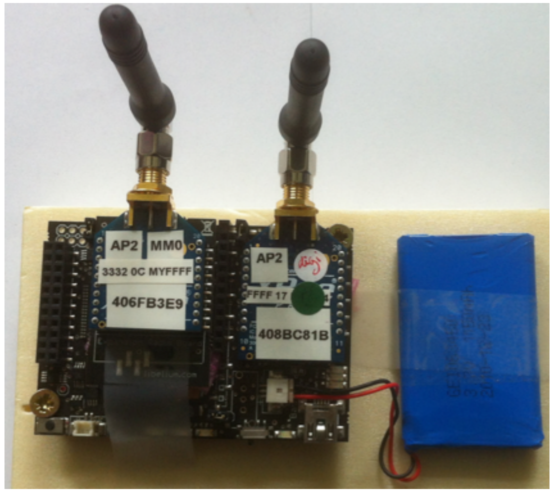
speex_sampledec_wframing

Summary of audio characteristics at the source

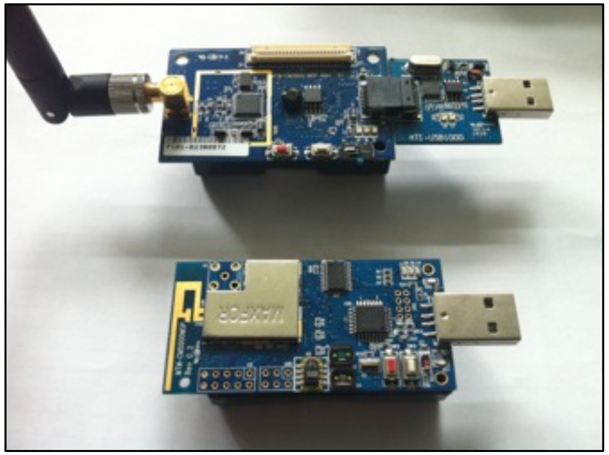
Codec	Minimum sending rate
Raw	
4KHz	100 bytes every 25ms
8KHz	100 bytes every 12.5ms
Speex 8000bps	
A1	24 bytes every 20ms
A2	48 bytes every 40ms
A3	72 bytes every 60ms
A4	96 bytes every 80ms

Existing relay nodes and their performances

Existing relay nodes



Libelium WaspMote



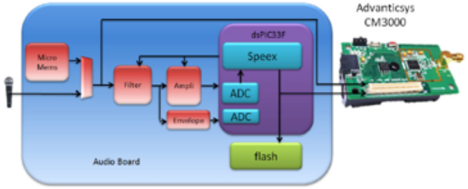
AdvanticSys CM5000, CM3000

Fully configurable:

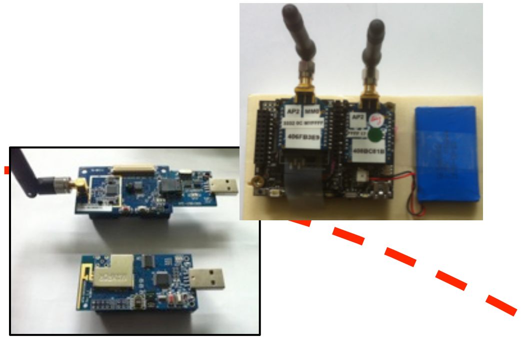
Destination node
Additional relay delay
Clock synchronization

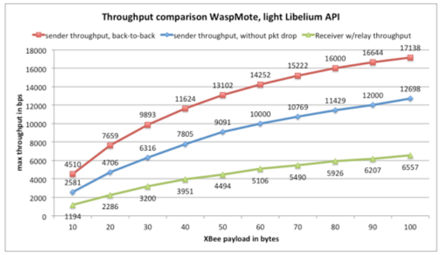
```
R0/1 enable/disable relay mode
D0013A2004086D828 set the 64-bit dest. mac addr
D0080 set the 16-bit dest. mac addr
```

Multi-hop audio constraints

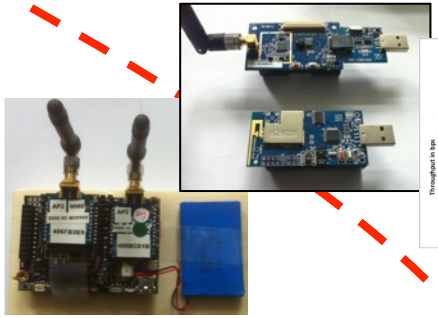


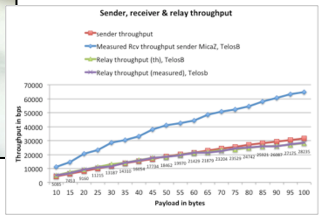
AUDIO SOURCE



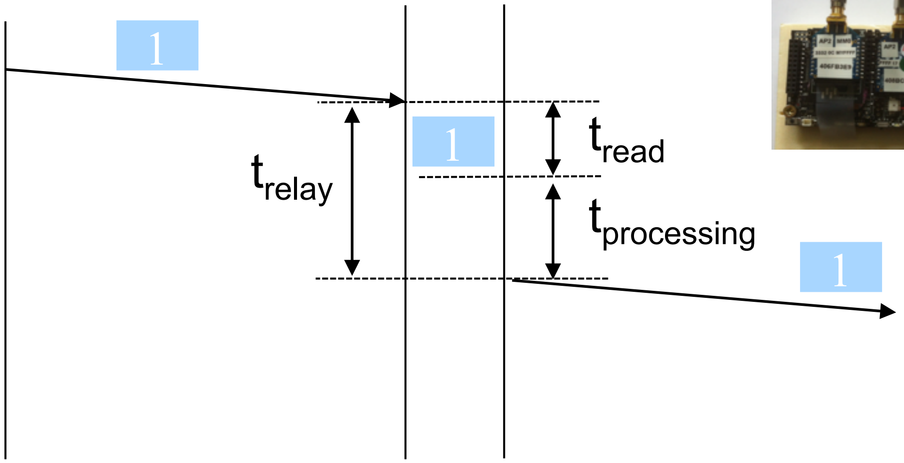


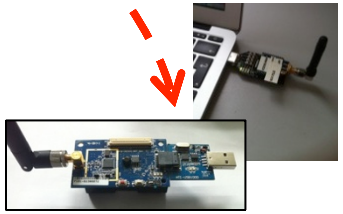
RELAY





RELAY





DECODE & PLAY
RECEIVED AUDIO

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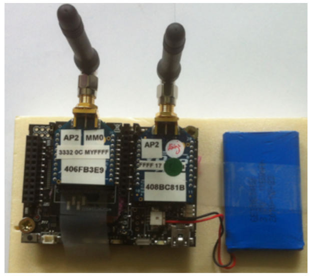
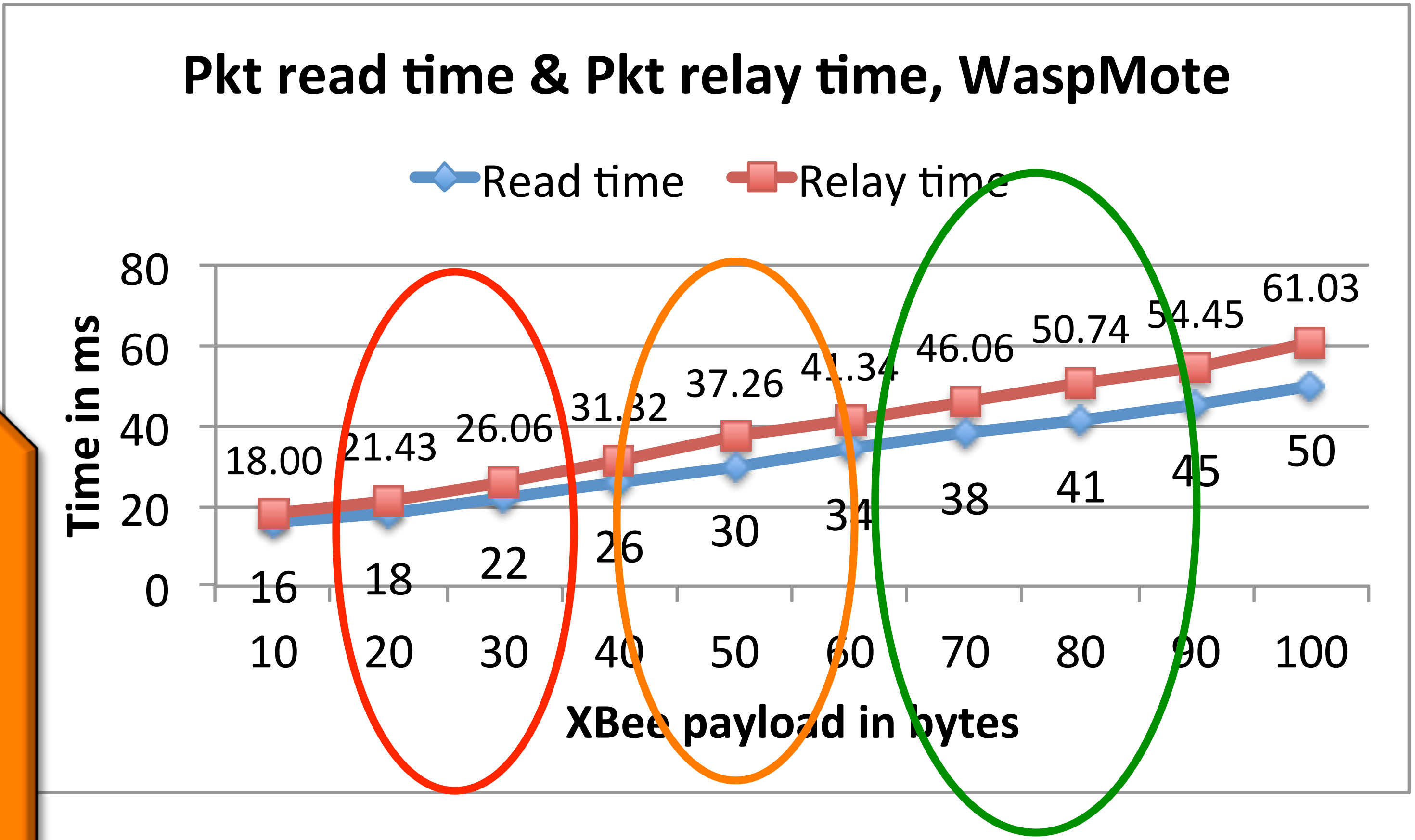
Relay node performances WaspMote (boosted), 125000 bauds

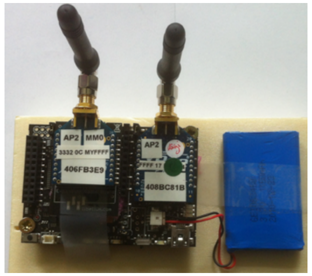


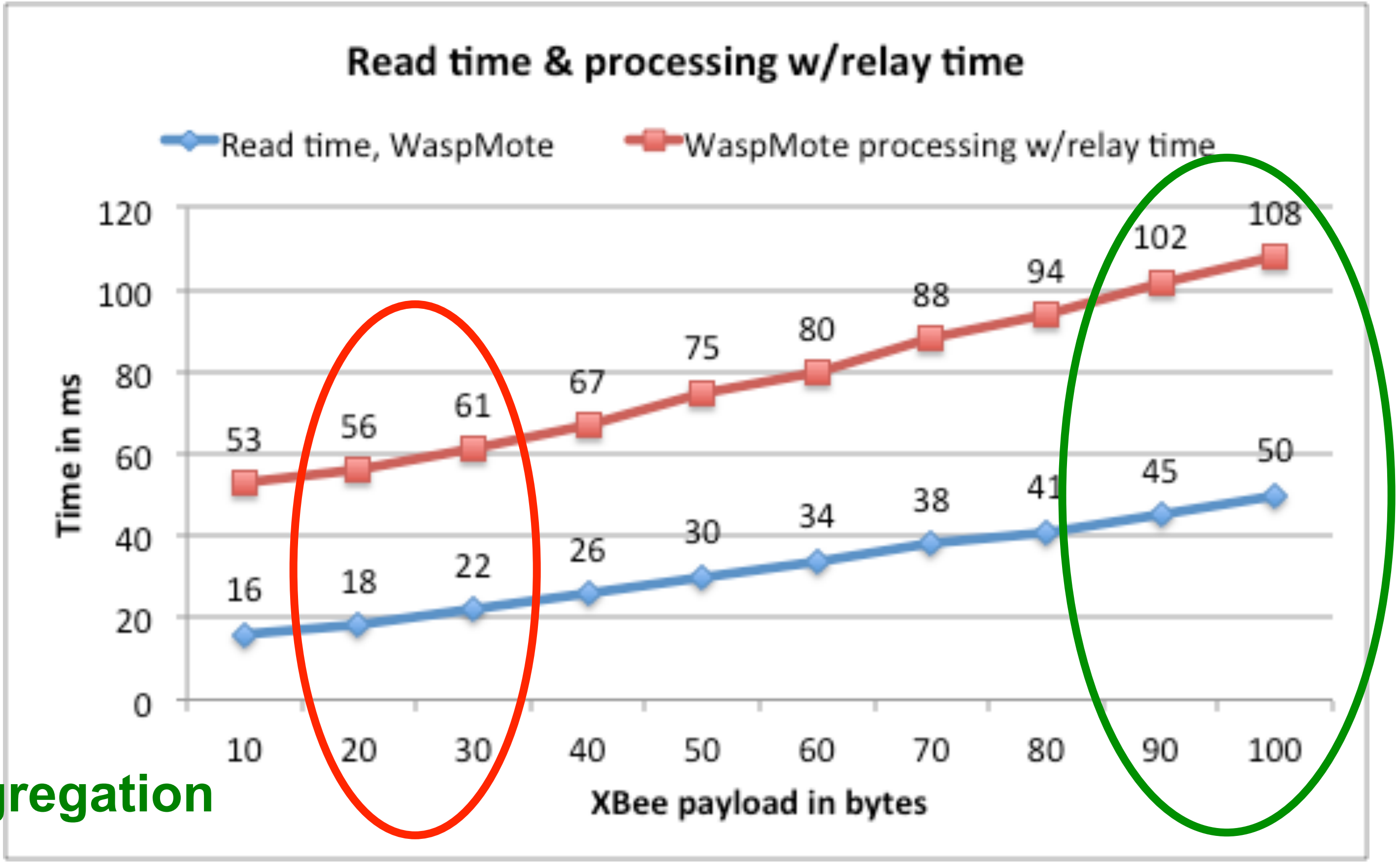


SPEEX codec at 8kbps requires to be able to relay a 25-byte packet every 20ms

Better with A3 aggregation

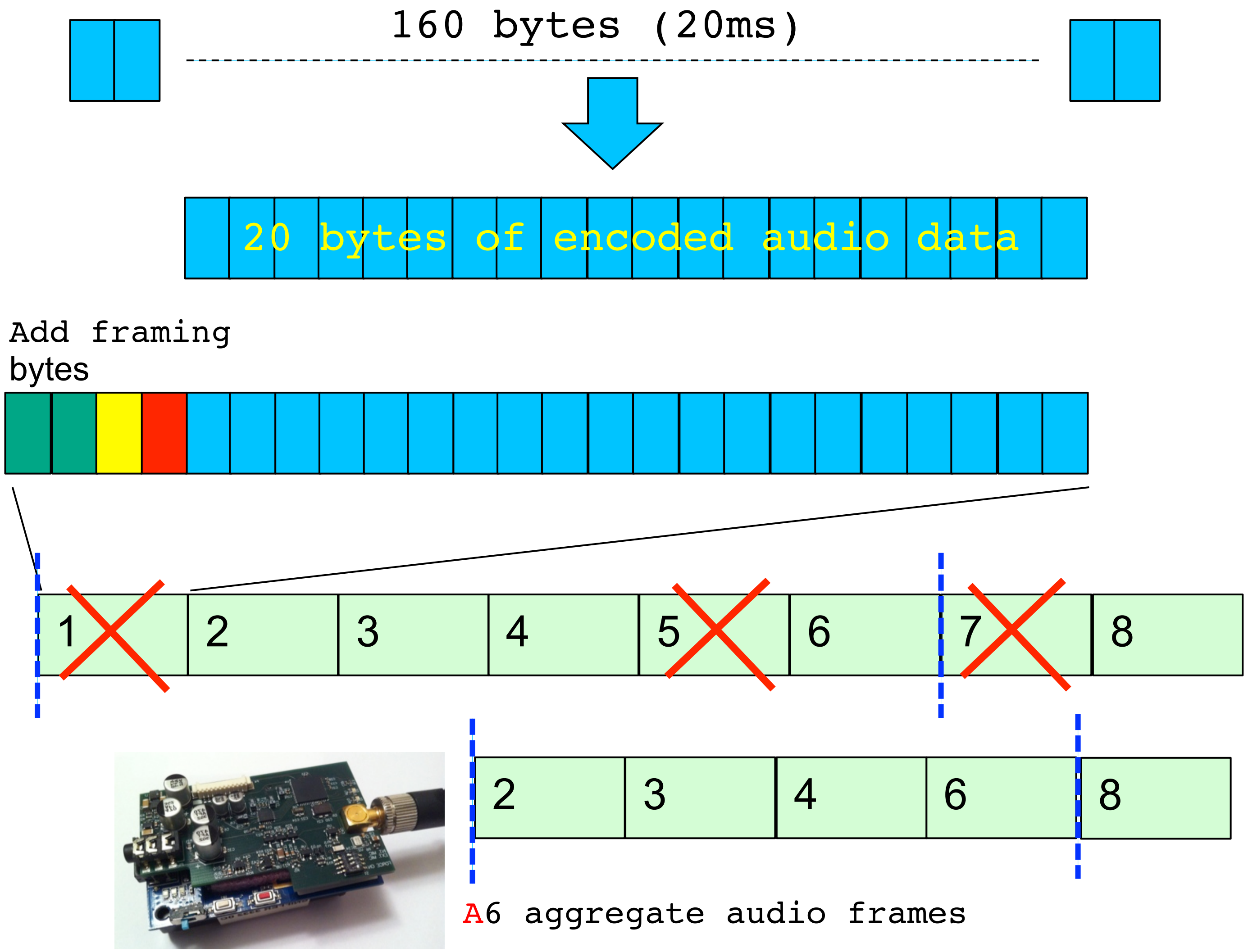
Relay node performances WaspMote (regular), 38400 bauds





Needs A6 aggregation

speex at 8kbps on slow relay nodes

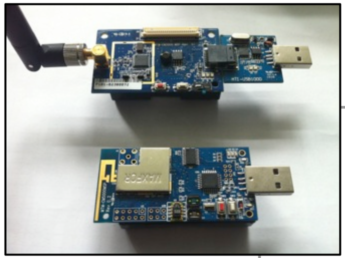


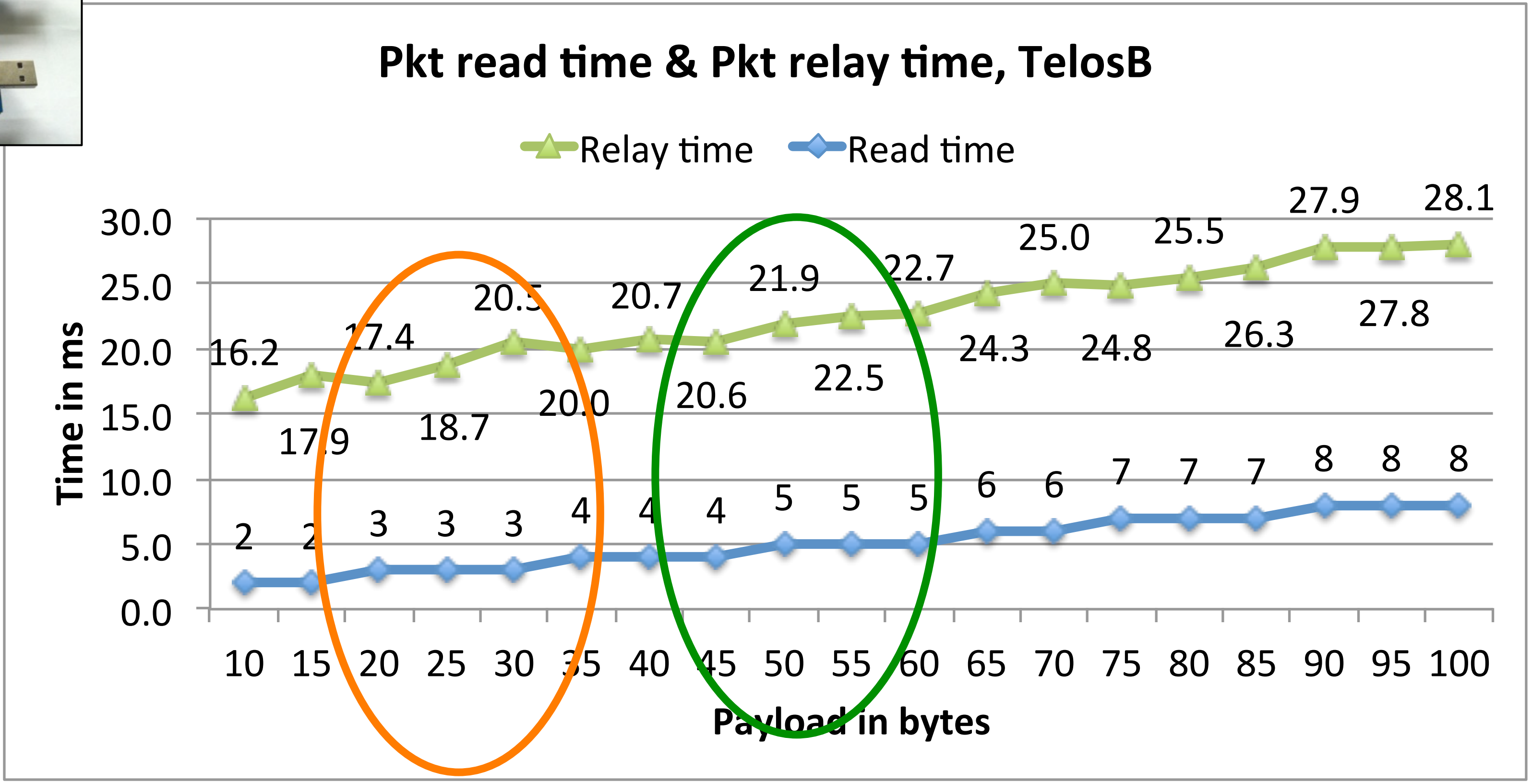
A6 aggregate audio frames

Capture 6 audio frames (120ms) but only send 4

Need to be able to relay 96-byte pkt every 120ms

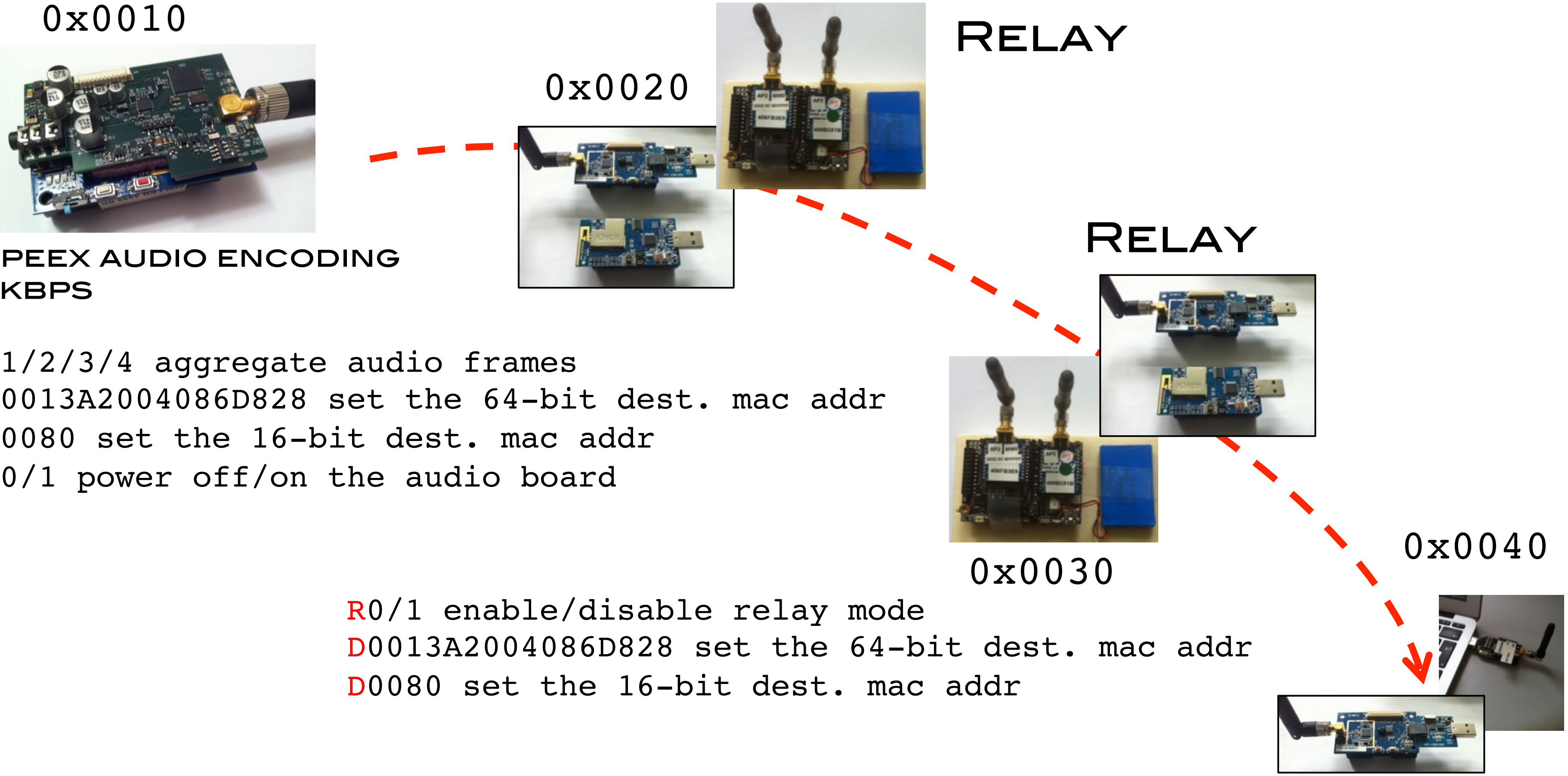
Relay node performances TelosB (TinyOS)





Better with A2 aggregation

Multi-hop test-bed w/audio board



```
A1/2/3/4 aggregate audio frames
D0013A2004086D828 set the 64-bit dest. mac addr
D0080 set the 16-bit dest. mac addr
C0/1 power off/on the audio board
```

```
R0/1 enable/disable relay mode
D0013A2004086D828 set the 64-bit dest. mac addr
D0080 set the 16-bit dest. mac addr
```

Procedure & tools for benchmarking a new test-bed

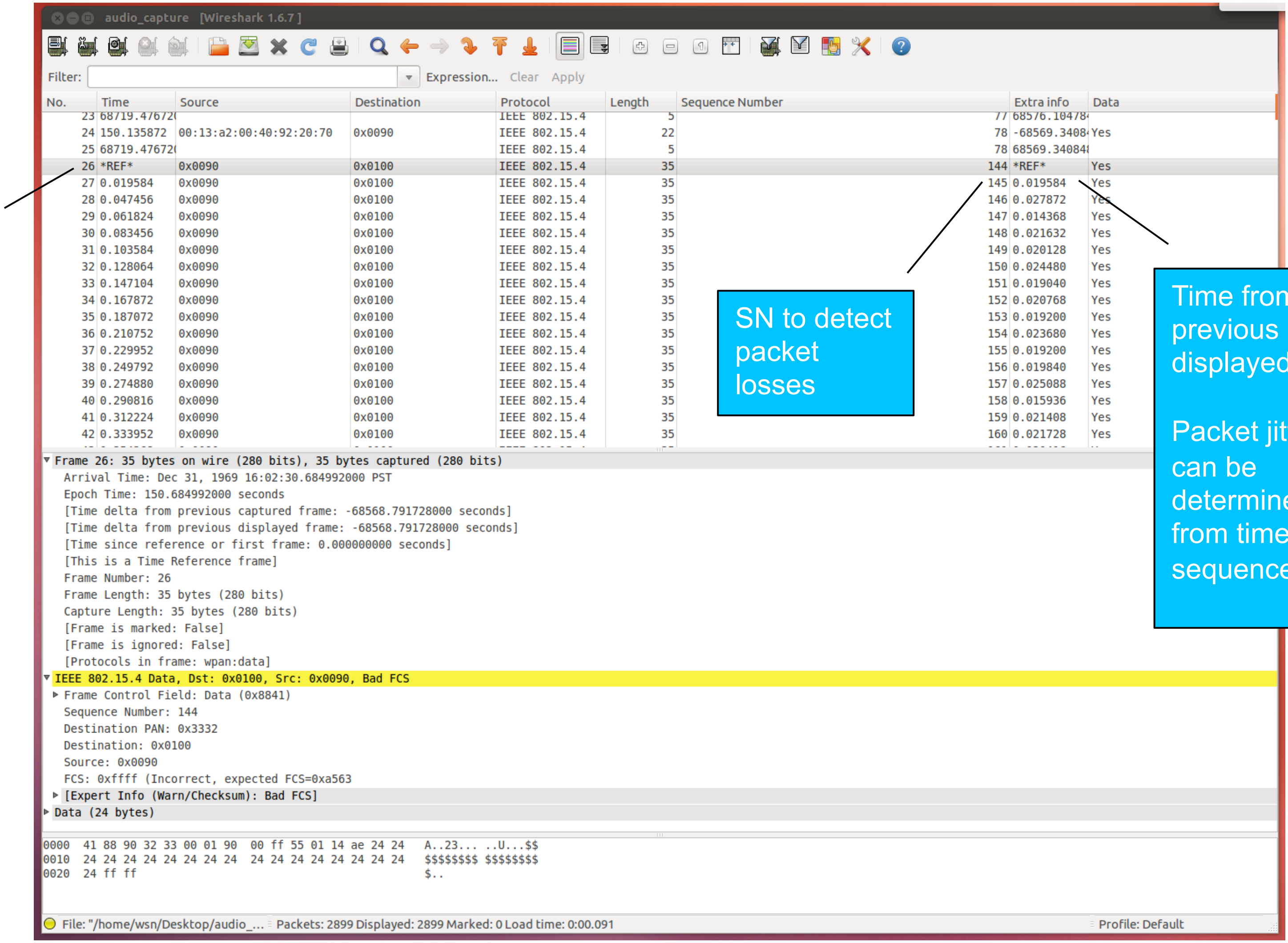
Benchmarking a new test-bed

- Determine 1-hop packet loss rate from audio source to either first relay node or gateway
  - Use maximum distance between audio source and first relay/gateway
- Determine performance of relay nodes
  - Packet relay latency
  - Packet relay jitter

Frame analysis

- Use `wireshark` as frame analysis tool
- Use an AdvanticSys TelosB mote as promiscuous sniffer mote, connected to `wireshark` to display captured frames
- Frame sequence number and reception time can be visualized for statistic collection
  - Number of lost frames, frame loss rate
  - Frame transmission latencies
  - Frame jitter

Example: packet losses & jitter



audio_capture [Wireshark 1.6.7]

Filter: Expression... Clear Apply

```
No. Time       Source                  Destination Protocol      Length Sequence Number Extra info     Data
 23 68719.47672(                                   IEEE 802.15.4      5              77 68576.10478
 24 150.135872 00:13:a2:00:40:92:20:70 0x0090      IEEE 802.15.4     22              78 -68569.3408 Yes
 25 68719.47672(                                   IEEE 802.15.4      5              78 68569.34084
 26 *REF*      0x0090                  0x0100      IEEE 802.15.4     35             144 *REF*       Yes
 27 0.019584   0x0090                  0x0100      IEEE 802.15.4     35             145 0.019584    Yes
 28 0.047456   0x0090                  0x0100      IEEE 802.15.4     35             146 0.027872    Yes
 29 0.061824   0x0090                  0x0100      IEEE 802.15.4     35             147 0.014368    Yes
 30 0.083456   0x0090                  0x0100      IEEE 802.15.4     35             148 0.021632    Yes
 31 0.103584   0x0090                  0x0100      IEEE 802.15.4     35             149 0.020128    Yes
 32 0.128064   0x0090                  0x0100      IEEE 802.15.4     35             150 0.024480    Yes
 33 0.147104   0x0090                  0x0100      IEEE 802.15.4     35             151 0.019040    Yes
 34 0.167872   0x0090                  0x0100      IEEE 802.15.4     35             152 0.020768    Yes
 35 0.187072   0x0090                  0x0100      IEEE 802.15.4     35             153 0.019200    Yes
 36 0.210752   0x0090                  0x0100      IEEE 802.15.4     35             154 0.023680    Yes
 37 0.229952   0x0090                  0x0100      IEEE 802.15.4     35             155 0.019200    Yes
 38 0.249792   0x0090                  0x0100      IEEE 802.15.4     35             156 0.019840    Yes
 39 0.274880   0x0090                  0x0100      IEEE 802.15.4     35             157 0.025088    Yes
 40 0.290816   0x0090                  0x0100      IEEE 802.15.4     35             158 0.015936    Yes
 41 0.312224   0x0090                  0x0100      IEEE 802.15.4     35             159 0.021408    Yes
 42 0.333952   0x0090                  0x0100      IEEE 802.15.4     35             160 0.021728    Yes
```

```
▼ Frame 26: 35 bytes on wire (280 bits), 35 bytes captured (280 bits)
    Arrival Time: Dec 31, 1969 16:02:30.684992000 PST
    Epoch Time: 150.684992000 seconds
    [Time delta from previous captured frame: -68568.791728000 seconds]
    [Time delta from previous displayed frame: -68568.791728000 seconds]
    [Time since reference or first frame: 0.000000000 seconds]
    [This is a Time Reference frame]
    Frame Number: 26
    Frame Length: 35 bytes (280 bits)
    Capture Length: 35 bytes (280 bits)
    [Frame is marked: False]
    [Frame is ignored: False]
    [Protocols in frame: wpan:data]
▼ IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS
  ▶ Frame Control Field: Data (0x8841)
    Sequence Number: 144
    Destination PAN: 0x3332
    Destination: 0x0100
    Source: 0x0090
    FCS: 0xffff (Incorrect, expected FCS=0xa563
  ▶ [Expert Info (Warn/Checksum): Bad FCS]
▶ Data (24 bytes)
```

```
0000  41 88 90 32 33 00 01 90  00 ff 55 01 14 ae 24 24   A..23... ..U...$$
0010  24 24 24 24 24 24 24 24  24 24 24 24 24 24 24 24   $$$$$$$$ $$$$$$$$
0020  24 ff ff                                            $..
```

File: "/home/wsn/Desktop/audio_... Packets: 2899 Displayed: 2899 Marked: 0 Load time: 0:00.091 Profile: Default

Time from reference time

SN to detect packet losses

Time from previous displayed

Packet jitter can be determine from time sequence

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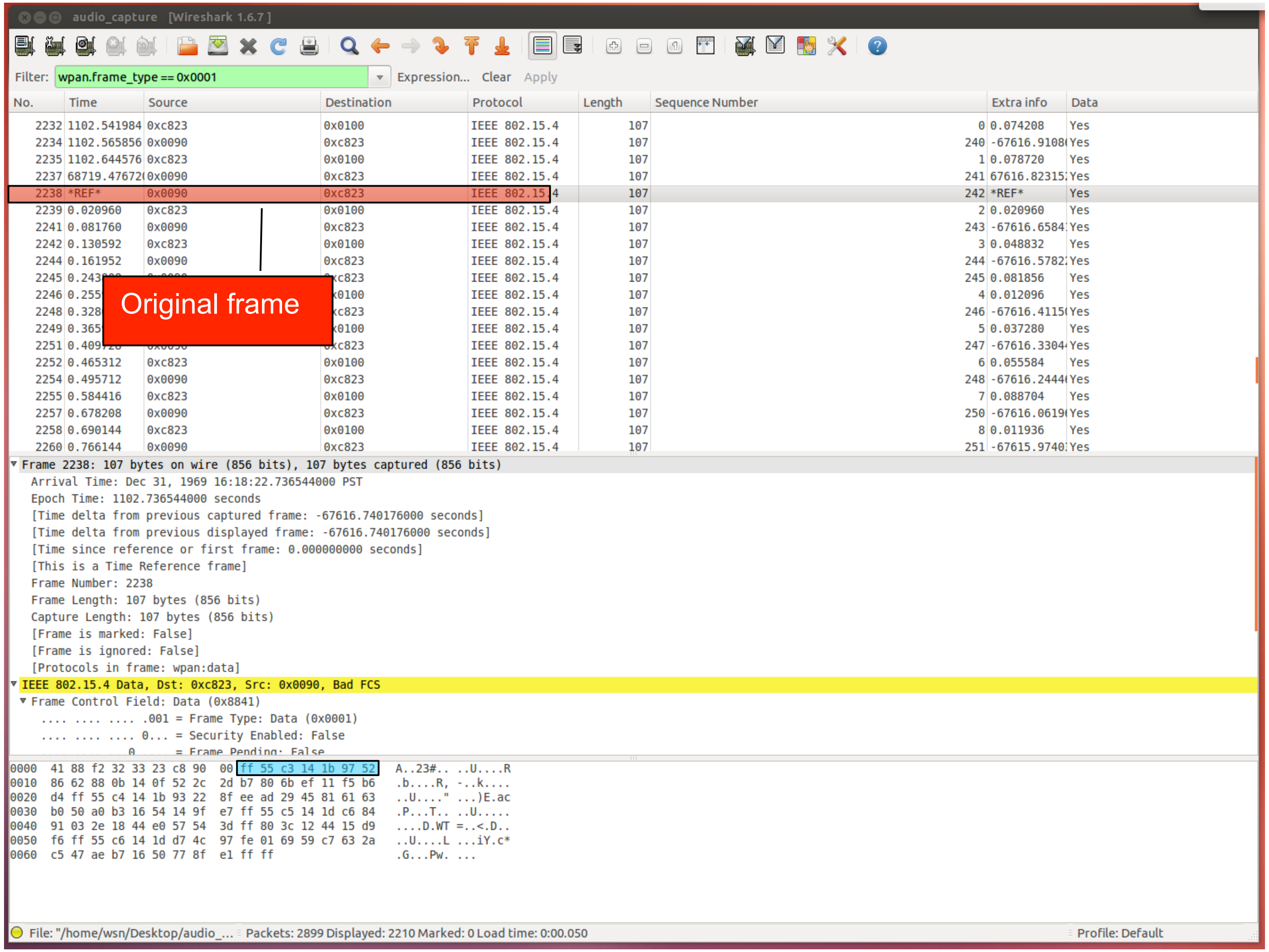
Example: relay latency



audio_capture [Wireshark 1.6.7]

Filter: wpan.frame_type == 0x0001

```
No.  Time        Source   Destination  Protocol       Length  Sequence Number  Extra info    Data
2232 1102.541984 0xc823   0x0100       IEEE 802.15.4  107                    0 0.074208      Yes
2234 1102.565856 0x0090   0xc823       IEEE 802.15.4  107                  240 -67616.9108(  Yes
2235 1102.644576 0xc823   0x0100       IEEE 802.15.4  107                    1 0.078720      Yes
2237 68719.47672( 0x0090  0xc823       IEEE 802.15.4  107                  241 67616.82315:  Yes
2238 *REF*       0x0090   0xc823       IEEE 802.15.4  107                  242 *REF*         Yes
2239 0.020960    0xc823   0x0100       IEEE 802.15.4  107                    2 0.020960      Yes
2241 0.081760    0x0090   0xc823       IEEE 802.15.4  107                  243 -67616.6584:  Yes
2242 0.130592    0xc823   0x0100       IEEE 802.15.4  107                    3 0.048832      Yes
2244 0.161952    0x0090   0xc823       IEEE 802.15.4  107                  244 -67616.5782:  Yes
2245 0.243                  xc823       IEEE 802.15.4  107                  245 0.081856      Yes
2246 0.255                  x0100       IEEE 802.15.4  107                    4 0.012096      Yes
2248 0.328                  xc823       IEEE 802.15.4  107                  246 -67616.4115(  Yes
2249 0.365                  x0100       IEEE 802.15.4  107                    5 0.037280      Yes
2251 0.409                  xc823       IEEE 802.15.4  107                  247 -67616.3304   Yes
2252 0.465312    0xc823   0x0100       IEEE 802.15.4  107                    6 0.055584      Yes
2254 0.495712    0x0090   0xc823       IEEE 802.15.4  107                  248 -67616.2444(  Yes
2255 0.584416    0xc823   0x0100       IEEE 802.15.4  107                    7 0.088704      Yes
2257 0.678208    0x0090   0xc823       IEEE 802.15.4  107                  250 -67616.0619(  Yes
2258 0.690144    0xc823   0x0100       IEEE 802.15.4  107                    8 0.011936      Yes
2260 0.766144    0x0090   0xc823       IEEE 802.15.4  107                  251 -67615.9740:  Yes
```

Original frame

```
▼ Frame 2238: 107 bytes on wire (856 bits), 107 bytes captured (856 bits)
    Arrival Time: Dec 31, 1969 16:18:22.736544000 PST
    Epoch Time: 1102.736544000 seconds
    [Time delta from previous captured frame: -67616.740176000 seconds]
    [Time delta from previous displayed frame: -67616.740176000 seconds]
    [Time since reference or first frame: 0.000000000 seconds]
    [This is a Time Reference frame]
    Frame Number: 2238
    Frame Length: 107 bytes (856 bits)
    Capture Length: 107 bytes (856 bits)
    [Frame is marked: False]
    [Frame is ignored: False]
    [Protocols in frame: wpan:data]
▼ IEEE 802.15.4 Data, Dst: 0xc823, Src: 0x0090, Bad FCS
  ▼ Frame Control Field: Data (0x8841)
      .... .... .... .001 = Frame Type: Data (0x0001)
      .... .... .... 0... = Security Enabled: False
      .... .... ...0 .... = Frame Pending: False
```

```
0000  41 88 f2 32 33 23 c8 90  00 ff 55 c3 14 1b 97 52   A..23#.. ..U....R
0010  86 62 88 0b 14 0f 52 2c  2d b7 80 6b ef 11 f5 b6   .b....R, -..k....
0020  d4 ff 55 c4 14 1b 93 22  8f ee ad 29 45 81 61 63   ..U...." ...)E.ac
0030  b0 50 a0 b3 16 54 14 9f  e7 ff 55 c5 14 1d c6 84   .P...T.. ..U.....
0040  91 03 2e 18 44 e0 57 54  3d ff 80 3c 12 44 15 d9   ....D.WT =..<.D..
0050  f6 ff 55 c6 14 1d d7 4c  97 fe 01 69 59 c7 63 2a   ..U....L ...iY.c*
0060  c5 47 ae b7 16 50 77 8f  e1 ff ff                  .G...Pw. ...
```

File: "/home/wsn/Desktop/audio_... Packets: 2899 Displayed: 2210 Marked: 0 Load time: 0:00.050 Profile: Default

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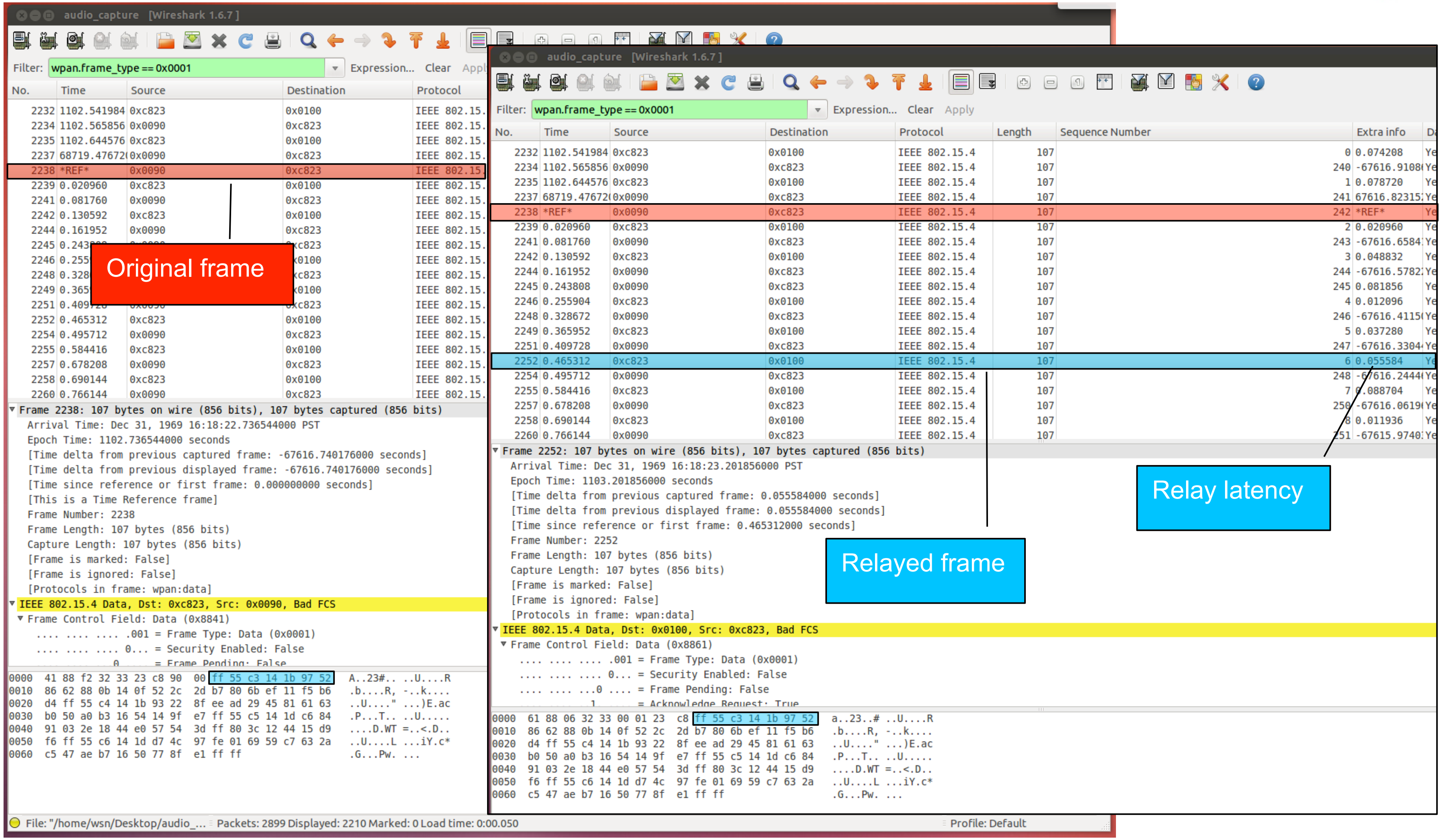
Example: relay latency



audio_capture [Wireshark 1.6.7]
Filter: wpan.frame_type == 0x0001
Expression...
Clear
Apply
Original frame
Relay latency
Relayed frame

```
No.  Time         Source   Destination  Protocol
2232 1102.541984  0xc823   0x0100       IEEE 802.15.
2234 1102.565856  0x0090   0xc823       IEEE 802.15.
2235 1102.644576  0xc823   0x0100       IEEE 802.15.
2237 68719.47672( 0x0090   0xc823       IEEE 802.15.
2238 *REF*        0x0090   0xc823       IEEE 802.15.
2239 0.020960     0xc823   0x0100       IEEE 802.15.
2241 0.081760     0x0090   0xc823       IEEE 802.15.
2242 0.130592     0xc823   0x0100       IEEE 802.15.
2244 0.161952     0x0090   0xc823       IEEE 802.15.
2245 0.243                 c823         IEEE 802.15.
2246 0.255                 0100         IEEE 802.15.
2248 0.328                 c823         IEEE 802.15.
2249 0.365                 0100         IEEE 802.15.
2251 0.409                 c823         IEEE 802.15.
2252 0.465312     0xc823   0x0100       IEEE 802.15.
2254 0.495712     0x0090   0xc823       IEEE 802.15.
2255 0.584416     0xc823   0x0100       IEEE 802.15.
2257 0.678208     0x0090   0xc823       IEEE 802.15.
2258 0.690144     0xc823   0x0100       IEEE 802.15.
2260 0.766144     0x0090   0xc823       IEEE 802.15.
```

```
▼ Frame 2238: 107 bytes on wire (856 bits), 107 bytes captured (856 bits)
    Arrival Time: Dec 31, 1969 16:18:22.736544000 PST
    Epoch Time: 1102.736544000 seconds
    [Time delta from previous captured frame: -67616.740176000 seconds]
    [Time delta from previous displayed frame: -67616.740176000 seconds]
    [Time since reference or first frame: 0.000000000 seconds]
    [This is a Time Reference frame]
    Frame Number: 2238
    Frame Length: 107 bytes (856 bits)
    Capture Length: 107 bytes (856 bits)
    [Frame is marked: False]
    [Frame is ignored: False]
    [Protocols in frame: wpan:data]
▼ IEEE 802.15.4 Data, Dst: 0xc823, Src: 0x0090, Bad FCS
  ▼ Frame Control Field: Data (0x8841)
      .... .... .... .001 = Frame Type: Data (0x0001)
      .... .... .... 0... = Security Enabled: False
      .... .... ...0 .... = Frame Pending: False
```

```
0000  41 88 f2 32 33 23 c8 90  00 ff 55 c3 14 1b 97 52   A..23#.. ..U....R
0010  86 62 88 0b 14 0f 52 2c  2d b7 80 6b ef 11 f5 b6   .b....R, -..k....
0020  d4 ff 55 c4 14 1b 93 22  8f ee ad 29 45 81 61 63   ..U...." ...)E.ac
0030  b0 50 a0 b3 16 54 14 9f  e7 ff 55 c5 14 1d c6 84   .P...T.. ..U.....
0040  91 03 2e 18 44 e0 57 54  3d ff 80 3c 12 44 15 d9   ....D.WT =..<.D..
0050  f6 ff 55 c6 14 1d d7 4c  97 fe 01 69 59 c7 63 2a   ..U....L ...iY.c*
0060  c5 47 ae b7 16 50 77 8f  e1 ff ff                  .G...Pw. ...
```

File: "/home/wsn/Desktop/audio_... Packets: 2899 Displayed: 2210 Marked: 0 Load time: 0:00.050 Profile: Default

```
No.  Time         Source   Destination  Protocol      Length  Sequence Number  Extra info         D
2232 1102.541984  0xc823   0x0100       IEEE 802.15.4    107                 0 0.074208         Ye
2234 1102.565856  0x0090   0xc823       IEEE 802.15.4    107               240 -67616.9108(     Ye
2235 1102.644576  0xc823   0x0100       IEEE 802.15.4    107                 1 0.078720         Ye
2237 68719.47672( 0x0090   0xc823       IEEE 802.15.4    107               241 67616.82315:     Ye
2238 *REF*        0x0090   0xc823       IEEE 802.15.4    107               242 *REF*            Ye
2239 0.020960     0xc823   0x0100       IEEE 802.15.4    107                 2 0.020960         Ye
2241 0.081760     0x0090   0xc823       IEEE 802.15.4    107               243 -67616.6584:     Ye
2242 0.130592     0xc823   0x0100       IEEE 802.15.4    107                 3 0.048832         Ye
2244 0.161952     0x0090   0xc823       IEEE 802.15.4    107               244 -67616.5782:     Ye
2245 0.243808     0x0090   0xc823       IEEE 802.15.4    107               245 0.081856         Ye
2246 0.255904     0xc823   0x0100       IEEE 802.15.4    107                 4 0.012096         Ye
2248 0.328672     0x0090   0xc823       IEEE 802.15.4    107               246 -67616.4115(     Ye
2249 0.365952     0xc823   0x0100       IEEE 802.15.4    107                 5 0.037280         Ye
2251 0.409728     0x0090   0xc823       IEEE 802.15.4    107               247 -67616.3304      Ye
2252 0.465312     0xc823   0x0100       IEEE 802.15.4    107                 6 0.055584         Ye
2254 0.495712     0x0090   0xc823       IEEE 802.15.4    107               248 -67616.2444(     Ye
2255 0.584416     0xc823   0x0100       IEEE 802.15.4    107                 7 0.088704         Ye
2257 0.678208     0x0090   0xc823       IEEE 802.15.4    107               250 -67616.0619(     Ye
2258 0.690144     0xc823   0x0100       IEEE 802.15.4    107                 8 0.011936         Ye
2260 0.766144     0x0090   0xc823       IEEE 802.15.4    107               251 -67615.9740:     Ye
```

```
▼ Frame 2252: 107 bytes on wire (856 bits), 107 bytes captured (856 bits)
    Arrival Time: Dec 31, 1969 16:18:23.201856000 PST
    Epoch Time: 1103.201856000 seconds
    [Time delta from previous captured frame: 0.055584000 seconds]
    [Time delta from previous displayed frame: 0.055584000 seconds]
    [Time since reference or first frame: 0.465312000 seconds]
    Frame Number: 2252
    Frame Length: 107 bytes (856 bits)
    Capture Length: 107 bytes (856 bits)
    [Frame is marked: False]
    [Frame is ignored: False]
    [Protocols in frame: wpan:data]
▼ IEEE 802.15.4 Data, Dst: 0x0100, Src: 0xc823, Bad FCS
  ▼ Frame Control Field: Data (0x8861)
      .... .... .... .001 = Frame Type: Data (0x0001)
      .... .... .... 0... = Security Enabled: False
      .... .... ...0 .... = Frame Pending: False
      .... .... ..1. .... = Acknowledge Request: True
```

```
0000  61 88 06 32 33 00 01 23  c8 ff 55 c3 14 1b 97 52   a..23..# ..U....R
0010  86 62 88 0b 14 0f 52 2c  2d b7 80 6b ef 11 f5 b6   .b....R, -..k....
0020  d4 ff 55 c4 14 1b 93 22  8f ee ad 29 45 81 61 63   ..U...." ...)E.ac
0030  b0 50 a0 b3 16 54 14 9f  e7 ff 55 c5 14 1d c6 84   .P...T.. ..U.....
0040  91 03 2e 18 44 e0 57 54  3d ff 80 3c 12 44 15 d9   ....D.WT =..<.D..
0050  f6 ff 55 c6 14 1d d7 4c  97 fe 01 69 59 c7 63 2a   ..U....L ...iY.c*
0060  c5 47 ae b7 16 50 77 8f  e1 ff ff                  .G...Pw. ...
```

Illustration: 1-hop packet loss rate

Sniffer node will capture all frames in order to determine packet loss rate for typical/maximum 1-hop distance

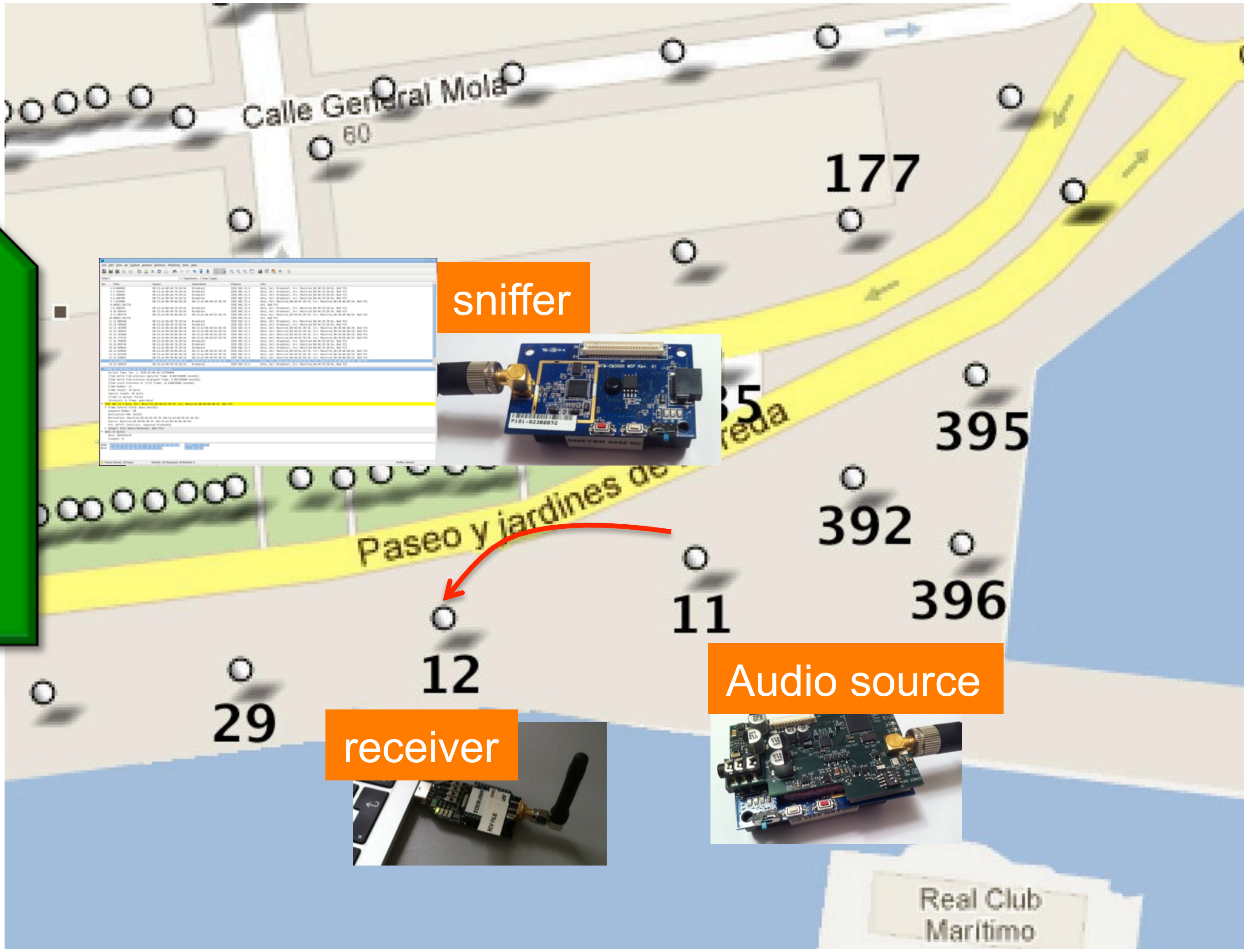
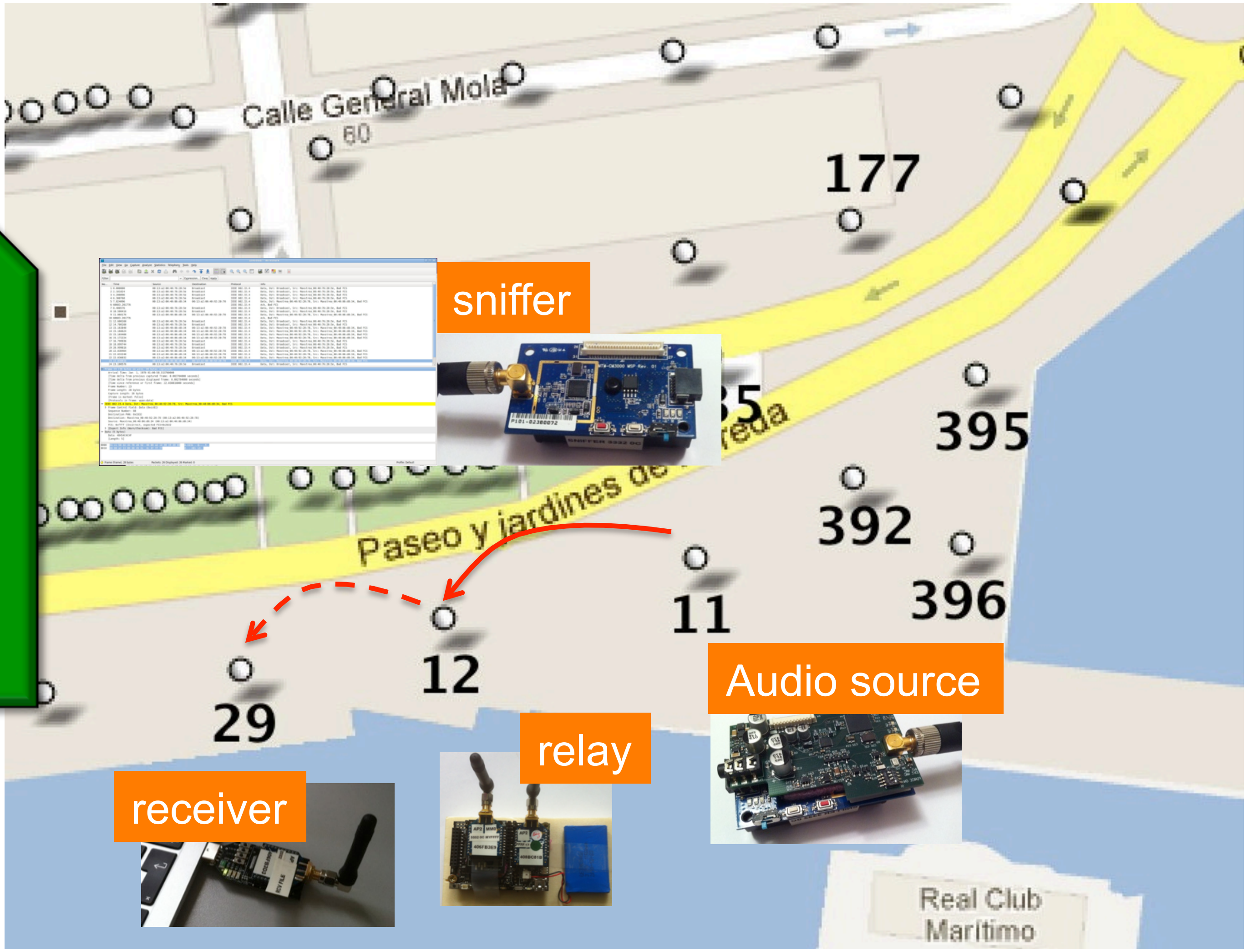


Illustration: relay latency & jitter

Sniffer node will capture all frames (those from audio source and those from relay node) in order to measure relay latency & jitter



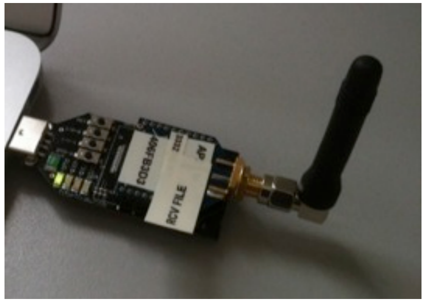
Configuring & controlling the audio source

- The audio source can be controlled wirelessly with text-based message
  - "@/A" for aggregation mode
  - "@/D" to set destination address
  - "@/C" to start/stop audio capture

```
A1/2/3/4 aggregate audio frames
D0013A2004086D828 set the 64-bit dest. mac addr
D0080 set the 16-bit dest. mac addr
C0/1 power off/on the audio board
```

- Use a 802.15.4 gateway to send control messages

XBeeSendCmd



- XBeeSendCmd
  - Main target is 802.15.4 XBee-based gateway
  - Send ASCII command with Xbee
  - Can be used to sent remote AT command to other Xbee module
  - Support DigiMesh firmware
  - Example
    - XBeeSendCmd -addr 0013a2004069165d "/@D0100#"

```
USAGE: ./XBeeSendCmd -baud baudrate -p dev [-L][-DM][-at] -tinyos -tinyos_amid id_hex -mac|-net|-addr|-b -size s -n n -t t
USAGE: -baud, set baud rate, default is 38400
USAGE: -p /dev/ttyUSB1, set setial port, default is /dev/ttyUSB0
USAGE: -L, insert Libelium API header for WaspMote under full Libelium API
USAGE: -DM, specify DigiMesh firmware
USAGE: -at, send remote AT command: -at -mac 0013a2004069165d ATMM
USAGE: -tinyos to forge a TinyOS ActiveMessage compatible packet (0x3F0x05 are inserted)
USAGE: -tinyos_amid 6F, to set the ActiveMessage identifier to 0x6F (0x05 is the default)
USAGE: -mac 0013a2004069165d, set 64-bit dest. MAC address
USAGE: -net 5678, set 16-bit dest. address
USAGE: -addr 64_or_16_bit_addr, set either 64-bit or 16-bit dest. address
USAGE: -b, use broadcast
USAGE: -size 50, set packet size to 50 bytes
USAGE: -n 10, send 10 packets
USAGE: -t 500, set 500ms between each packet
```

XBeeSendCmd example

- Assuming 0x0090 is the address of the audio source and 0x0100 is the address of the sink
- Set destination address
  - `XBeeSendCmd -p /dev/ttyUSB0 -addr 0090 ''/@D0100#''`
- Start audio capture
  - `XBeeSendCmd -p /dev/ttyUSB0 -addr 0090 ''/@C1#''`
- Set aggregation mode 2
  - `XBeeSendCmd -p /dev/ttyUSB0 -addr 0090 ''/@A2#''`

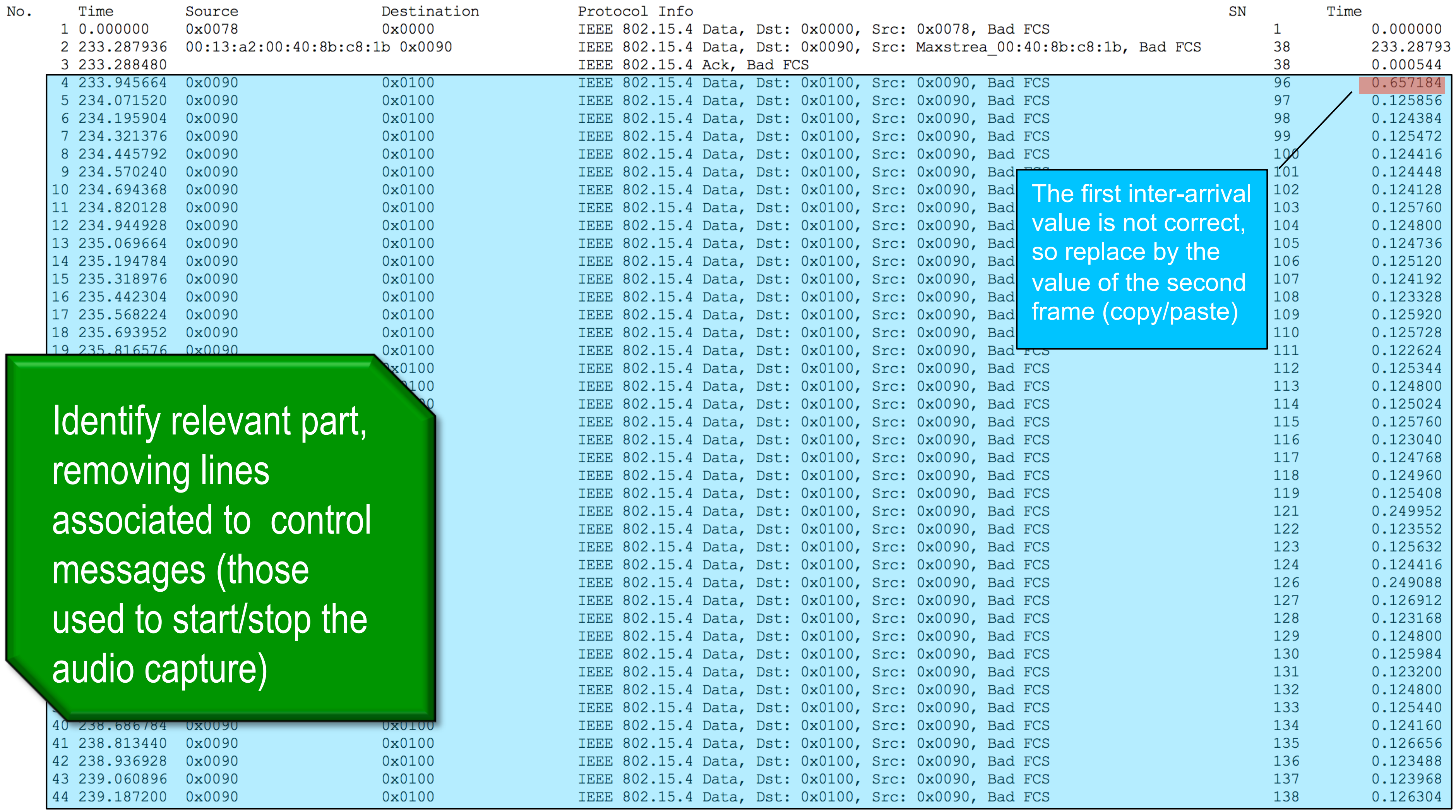
Simplified way to measure relay latency

- Instead of using the audio source to measure the relay latency, XBeeSendCmd can be used to send a number of packets of a given size at a given rate
- Example: broadcast 10 packets of 100 bytes, one every 500ms
  - `XBeeSendCmd -p /dev/ttyUSB0 -b -size 100 -n 10 -t 500`
- Use wireshark as previously described

Get statistics from wireshark captured frames

- Add custom columns info to have
  - IEEE 802.15.4 frame sequence number (wpan.seq_no)
  - Time from previously displayed frame
- Export the wireshark capture in text format, applying filters as needed (if filters, export only displayed frames)
- Also save the wireshark capture in pcap format for future usage as the pcap format stores all the information to apply additional filters if needed

Example: text file



```
No.     Time        Source                    Destination        Protocol Info                                                    SN        Time
      1 0.000000    0x0078                    0x0000             IEEE 802.15.4 Data, Dst: 0x0000, Src: 0x0078, Bad FCS            1             0.000000
      2 233.287936  00:13:a2:00:40:8b:c8:1b 0x0090               IEEE 802.15.4 Data, Dst: 0x0090, Src: Maxstrea_00:40:8b:c8:1b, Bad FCS    38    233.28793
      3 233.288480                                               IEEE 802.15.4 Ack, Bad FCS                                       38            0.000544
      4 233.945664  0x0090                    0x0100             IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS            96            0.657184
      5 234.071520  0x0090                    0x0100             IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS            97            0.125856
      6 234.195904  0x0090                    0x0100             IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS            98            0.124384
      7 234.321376  0x0090                    0x0100             IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS            99            0.125472
      8 234.445792  0x0090                    0x0100             IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS            100           0.124416
      9 234.570240  0x0090                    0x0100             IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad                101           0.124448
     10 234.694368  0x0090                    0x0100             IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad                102           0.124128
     11 234.820128  0x0090                    0x0100             IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad                103           0.125760
     12 234.944928  0x0090                    0x0100             IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad                104           0.124800
     13 235.069664  0x0090                    0x0100             IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad                105           0.124736
     14 235.194784  0x0090                    0x0100             IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad                106           0.125120
     15 235.318976  0x0090                    0x0100             IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad                107           0.124192
     16 235.442304  0x0090                    0x0100             IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad                108           0.123328
     17 235.568224  0x0090                    0x0100             IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad                109           0.125920
     18 235.693952  0x0090                    0x0100             IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad                110           0.125728
     19 235.816576  0x0090                    0x0100             IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS            111           0.122624
                                              x0100              IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS            112           0.125344
                                                100              IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS            113           0.124800
                                                  0              IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS            114           0.125024
                                                                 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS            115           0.125760
                                                                 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS            116           0.123040
                                                                 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS            117           0.124768
                                                                 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS            118           0.124960
                                                                 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS            119           0.125408
                                                                 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS            121           0.249952
                                                                 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS            122           0.123552
                                                                 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS            123           0.125632
                                                                 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS            124           0.124416
                                                                 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS            126           0.249088
                                                                 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS            127           0.126912
                                                                 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS            128           0.123168
                                                                 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS            129           0.124800
                                                                 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS            130           0.125984
                                                                 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS            131           0.123200
                                                                 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS            132           0.124800
                                                                 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS            133           0.125440
     40 238.686784  0x0090                    0x0100             IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS            134           0.124160
     41 238.813440  0x0090                    0x0100             IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS            135           0.126656
     42 238.936928  0x0090                    0x0100             IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS            136           0.123488
     43 239.060896  0x0090                    0x0100             IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS            137           0.123968
     44 239.187200  0x0090                    0x0100             IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS            138           0.126304
```

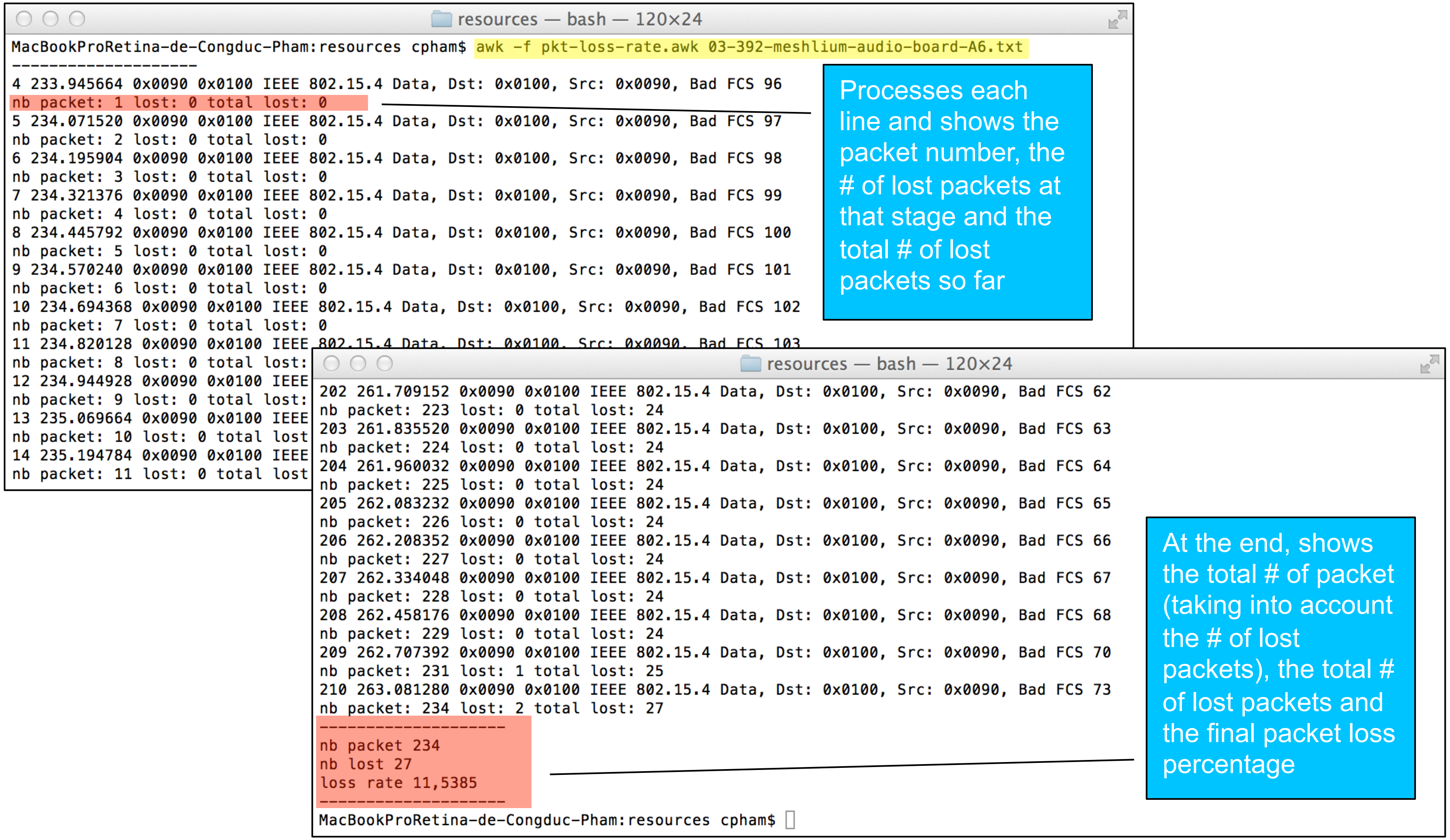
The first inter-arrival value is not correct, so replace by the value of the second frame (copy/paste)

Identify relevant part, removing lines associated to control messages (those used to start/stop the audio capture)

Simply determine packet loss rate

- Use the provided awk script to process the text file
- Be sure to have a text file with only the relevant frames (remove the control messages at the beginning and at the end of the captured trace)
- Example
  - `awk -f pkt-loss-rate.awk mytrace.txt`

Awk results



```
MacBookProRetina-de-Congduc-Pham:resources cpham$ awk -f pkt-loss-rate.awk 03-392-meshlium-audio-board-A6.txt
--------------------
4 233.945664 0x0090 0x0100 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS 96
nb packet: 1 lost: 0 total lost: 0
5 234.071520 0x0090 0x0100 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS 97
nb packet: 2 lost: 0 total lost: 0
6 234.195904 0x0090 0x0100 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS 98
nb packet: 3 lost: 0 total lost: 0
7 234.321376 0x0090 0x0100 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS 99
nb packet: 4 lost: 0 total lost: 0
8 234.445792 0x0090 0x0100 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS 100
nb packet: 5 lost: 0 total lost: 0
9 234.570240 0x0090 0x0100 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS 101
nb packet: 6 lost: 0 total lost: 0
10 234.694368 0x0090 0x0100 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS 102
nb packet: 7 lost: 0 total lost: 0
11 234.820128 0x0090 0x0100 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS 103
nb packet: 8 lost: 0 total lost:
12 234.944928 0x0090 0x0100 IEEE
nb packet: 9 lost: 0 total lost:
13 235.069664 0x0090 0x0100 IEEE
nb packet: 10 lost: 0 total lost
14 235.194784 0x0090 0x0100 IEEE
nb packet: 11 lost: 0 total lost
```

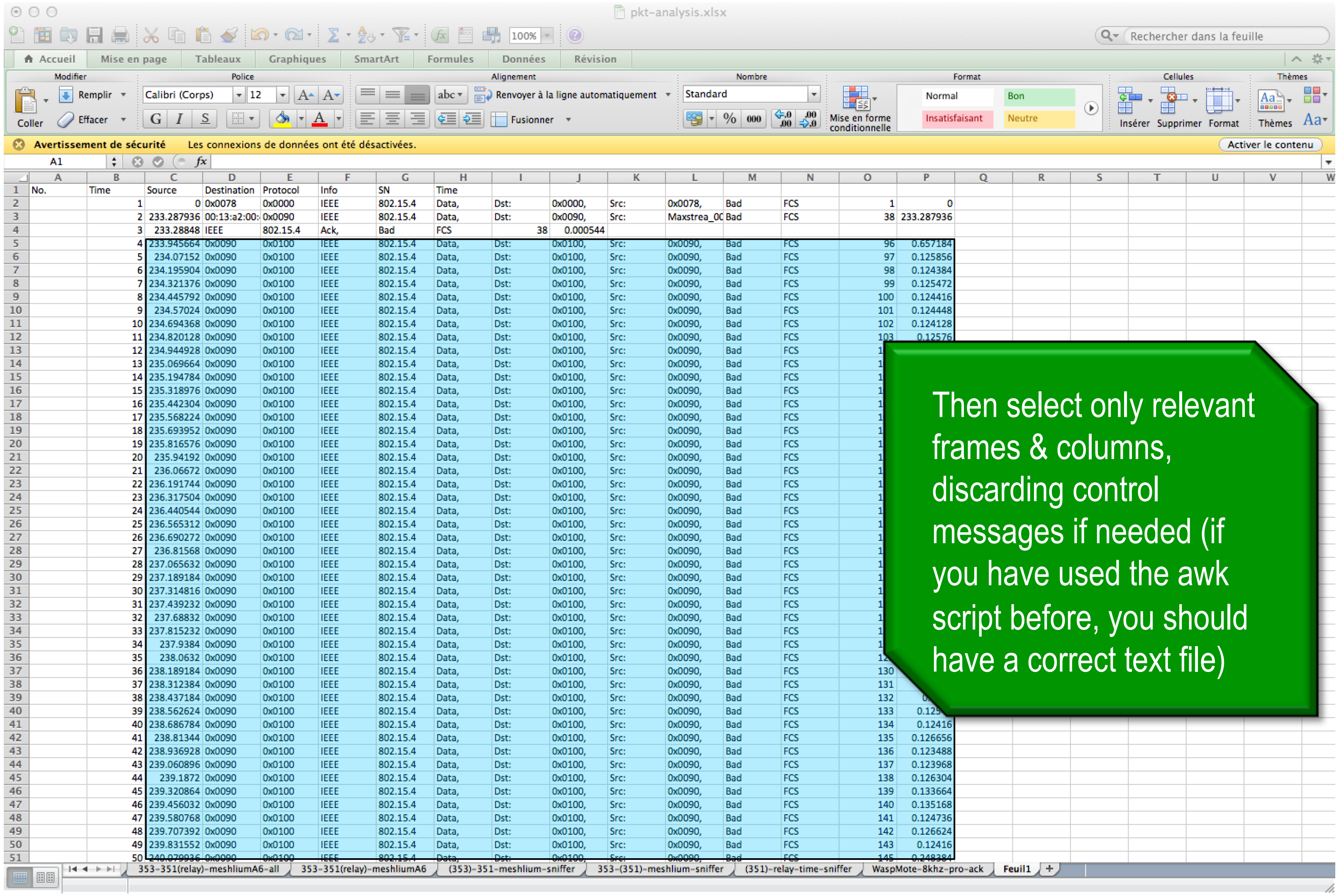
Processes each line and shows the packet number, the # of lost packets at that stage and the total # of lost packets so far

```
202 261.709152 0x0090 0x0100 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS 62
nb packet: 223 lost: 0 total lost: 24
203 261.835520 0x0090 0x0100 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS 63
nb packet: 224 lost: 0 total lost: 24
204 261.960032 0x0090 0x0100 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS 64
nb packet: 225 lost: 0 total lost: 24
205 262.083232 0x0090 0x0100 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS 65
nb packet: 226 lost: 0 total lost: 24
206 262.208352 0x0090 0x0100 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS 66
nb packet: 227 lost: 0 total lost: 24
207 262.334048 0x0090 0x0100 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS 67
nb packet: 228 lost: 0 total lost: 24
208 262.458176 0x0090 0x0100 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS 68
nb packet: 229 lost: 0 total lost: 24
209 262.707392 0x0090 0x0100 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS 70
nb packet: 231 lost: 1 total lost: 25
210 263.081280 0x0090 0x0100 IEEE 802.15.4 Data, Dst: 0x0100, Src: 0x0090, Bad FCS 73
nb packet: 234 lost: 2 total lost: 27
--------------------
nb packet 234
nb lost 27
loss rate 11,5385
--------------------
MacBookProRetina-de-Congduc-Pham:resources cpham$
```

At the end, shows the total # of packet (taking into account the # of lost packets), the total # of lost packets and the final packet loss percentage

Use Excel to vizualize loss patterns

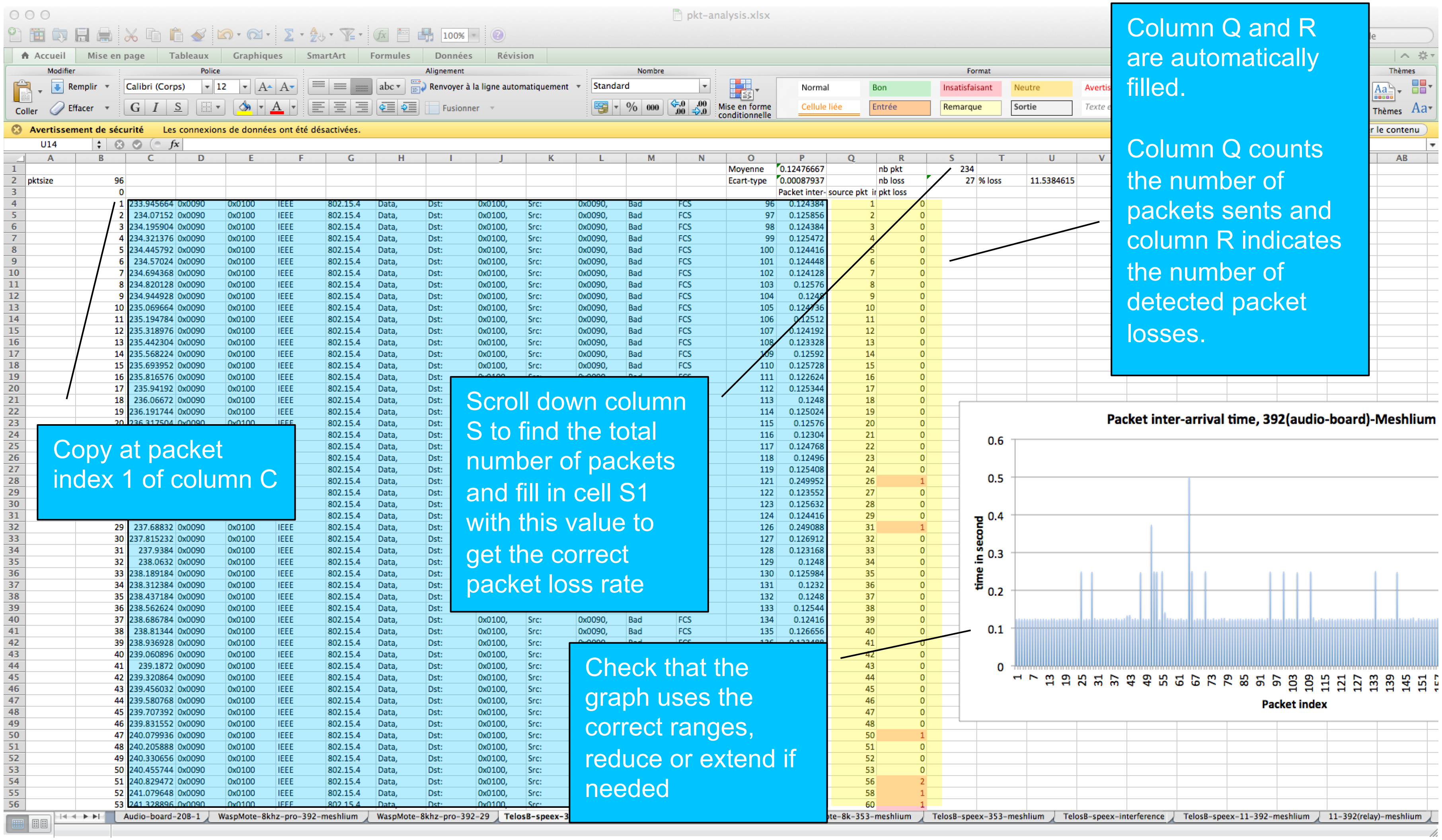
Copy/Paste the text into an Excel blank page, using text importation assistant to separate data into columns



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	No.	Time	Source	Destination	Protocol	Info	SN	Time								
2		1	0	0x0078	0x0000	IEEE	802.15.4	Data,	Dst:	0x0000,	Src:	0x0078,	Bad	FCS	1	0
3		2	233.287936	00:13:a2:00:	0x0090	IEEE	802.15.4	Data,	Dst:	0x0090,	Src:	Maxstrea_0C	Bad	FCS	38	233.287936
4		3	233.28848	IEEE	802.15.4	Ack,	Bad	FCS	38	0.000544						
5		4	233.945664	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	96	0.657184
6		5	234.07152	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	97	0.125856
7		6	234.195904	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	98	0.124384
8		7	234.321376	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	99	0.125472
9		8	234.445792	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	100	0.124416
10		9	234.57024	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	101	0.124448
11		10	234.694368	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	102	0.124128
12		11	234.820128	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	103	0.12576
13		12	234.944928	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	1	
14		13	235.069664	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	1	
15		14	235.194784	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	1	
16		15	235.318976	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	1	
17		16	235.442304	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	1	
18		17	235.568224	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	1	
19		18	235.693952	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	1	
20		19	235.816576	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	1	
21		20	235.94192	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	1	
22		21	236.06672	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	1	
23		22	236.191744	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	1	
24		23	236.317504	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	1	
25		24	236.440544	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	1	
26		25	236.565312	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	1	
27		26	236.690272	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	1	
28		27	236.81568	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	1	
29		28	237.065632	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	1	
30		29	237.189184	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	1	
31		30	237.314816	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	1	
32		31	237.439232	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	1	
33		32	237.68832	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	1	
34		33	237.815232	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	1	
35		34	237.9384	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	1	
36		35	238.0632	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	12	
37		36	238.189184	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	130	
38		37	238.312384	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	131	
39		38	238.437184	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	132	0.
40		39	238.562624	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	133	0.125
41		40	238.686784	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	134	0.12416
42		41	238.81344	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	135	0.126656
43		42	238.936928	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	136	0.123488
44		43	239.060896	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	137	0.123968
45		44	239.1872	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	138	0.126304
46		45	239.320864	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	139	0.133664
47		46	239.456032	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	140	0.135168
48		47	239.580768	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	141	0.124736
49		48	239.707392	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	142	0.126624
50		49	239.831552	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	143	0.12416
51		50	240.079936	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	145	0.248384

Then select only relevant frames & columns, discarding control messages if needed (if you have used the awk script before, you should have a correct text file)

Copy selection into the template page



pkt-analysis.xlsx
Accueil
Mise en page
Tableaux
Graphiques
SmartArt
Formules
Données
Révision
Avertissement de sécurité
Les connexions de données ont été désactivées.
U14
Packet inter-arrival time, 392(audio-board)-Meshlium
time in second
0.6
0.5
0.4
0.3
0.2
0.1
0
Packet index
Audio-board-20B-1
WaspMote-8khz-pro-392-meshlium
WaspMote-8khz-pro-392-29
TelosB-speex-3
te-8k-353-meshlium
TelosB-speex-353-meshlium
TelosB-speex-interference
TelosB-speex-11-392-meshlium
11-392(relay)-meshlium

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1															Moyenne	0.12476667		nb pkt	234		
2	pktsize	96													Ecart-type	0.00087937		nb loss	27	% loss	11.5384615
3		0														Packet inter-	source pkt ir	pkt loss			
4		1	233.945664	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	96	0.124384	1	0			
5		2	234.07152	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	97	0.125856	2	0			
6		3	234.195904	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	98	0.124384	3	0			
7		4	234.321376	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	99	0.125472	4	0			
8		5	234.445792	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	100	0.124416	5	0			
9		6	234.57024	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	101	0.124448	6	0			
10		7	234.694368	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	102	0.124128	7	0			
11		8	234.820128	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	103	0.12576	8	0			
12		9	234.944928	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	104	0.1248	9	0			
13		10	235.069664	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	105	0.124736	10	0			
14		11	235.194784	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	106	0.12512	11	0			
15		12	235.318976	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	107	0.124192	12	0			
16		13	235.442304	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	108	0.123328	13	0			
17		14	235.568224	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	109	0.12592	14	0			
18		15	235.693952	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	110	0.125728	15	0			
19		16	235.816576	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	111	0.122624	16	0			
20		17	235.94192	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:						112	0.125344	17	0			
21		18	236.06672	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:						113	0.1248	18	0			
22		19	236.191744	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:						114	0.125024	19	0			
23		20	236.317504	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:						115	0.12576	20	0			
24							802.15.4	Data,	Dst:						116	0.12304	21	0			
25							802.15.4	Data,	Dst:						117	0.124768	22	0			
26							802.15.4	Data,	Dst:						118	0.12496	23	0			
27							802.15.4	Data,	Dst:						119	0.125408	24	0			
28							802.15.4	Data,	Dst:						121	0.249952	26	1			
29							802.15.4	Data,	Dst:						122	0.123552	27	0			
30							802.15.4	Data,	Dst:						123	0.125632	28	0			
31							802.15.4	Data,	Dst:						124	0.124416	29	0			
32		29	237.68832	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:						126	0.249088	31	1			
33		30	237.815232	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:						127	0.126912	32	0			
34		31	237.9384	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:						128	0.123168	33	0			
35		32	238.0632	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:						129	0.1248	34	0			
36		33	238.189184	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:						130	0.125984	35	0			
37		34	238.312384	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:						131	0.1232	36	0			
38		35	238.437184	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:						132	0.1248	37	0			
39		36	238.562624	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:						133	0.12544	38	0			
40		37	238.686784	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	134	0.12416	39	0			
41		38	238.81344	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	135	0.126656	40	0			
42		39	238.936928	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:	0x0090,	Bad	FCS	136	0.123488	41	0			
43		40	239.060896	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:						42	0			
44		41	239.1872	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:						43	0			
45		42	239.320864	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:						44	0			
46		43	239.456032	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:						45	0			
47		44	239.580768	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:						46	0			
48		45	239.707392	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:						47	0			
49		46	239.831552	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:						48	0			
50		47	240.079936	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:						50	1			
51		48	240.205888	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:						51	0			
52		49	240.330656	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:						52	0			
53		50	240.455744	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:						53	0			
54		51	240.829472	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:						56	2			
55		52	241.079648	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:						58	1			
56		53	241.328896	0x0090	0x0100	IEEE	802.15.4	Data,	Dst:	0x0100,	Src:						60	1			

Column Q and R are automatically filled.

Column Q counts the number of packets sents and column R indicates the number of detected packet losses.

Copy at packet index 1 of column C

Scroll down column S to find the total number of packets and fill in cell S1 with this value to get the correct packet loss rate

Check that the graph uses the correct ranges, reduce or extend if needed

Check test-bed performances

- Refer to EAR-IT deliverable 1.2
- With 1-hop packet loss rates, check whether the value is acceptable, i.e. below 50% for raw audio and below 35% for speex audio
- Check whether the relay time of your test-bed is compatible with audio requirements, use aggregation if needed

All resources are available for download with instructions of usage