

DEMO: IMAGES AND AUDIO TRANSMISSION ON WIRELESS SENSOR NETWORKS

SUMMER SCHOOL
“SENSOR NETWORKS: IMPACTS AND
CHALLENGES FOR SOCIETY”
UNIVERSITY OF BÉJAIA, ALGERIA
JULY 4TH, 2013



PROF. CONGDUC PHAM
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UNIVERSITÉ DE PAU, FRANCE



DÉMO: TRANSMISSION D'IMAGES ET AUDIO SUR RÉSEAUX DE CAPTEURS

ECOLE D'ÉTÉ RÉSEAUX DE CAPTEURS:
IMPACTS ET DÉFIS POUR LA SOCIÉTÉ
3 JUILLET, 2013
BÉJAIA, ALGÉRIE



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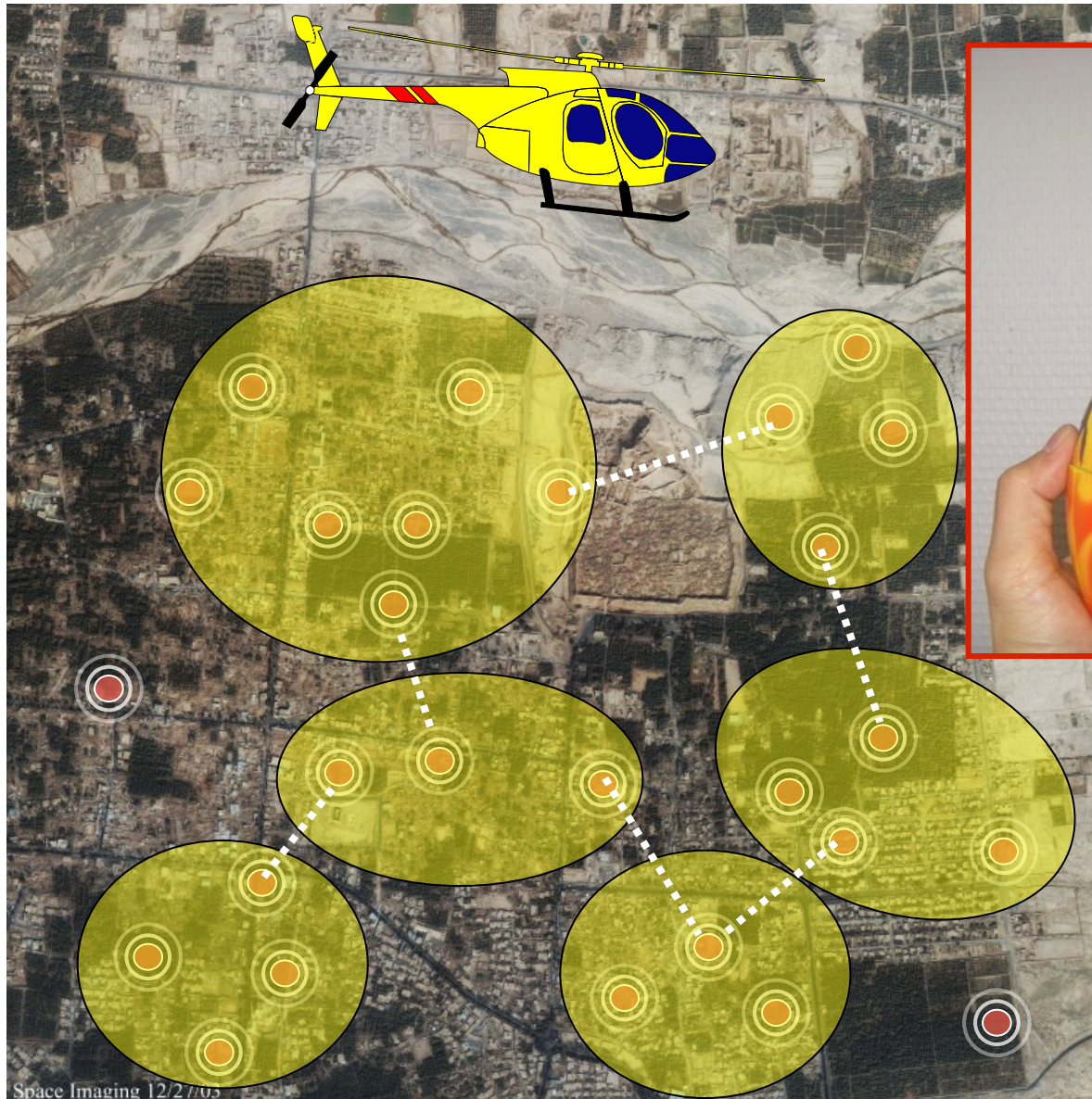
SEARCH & RESCUE



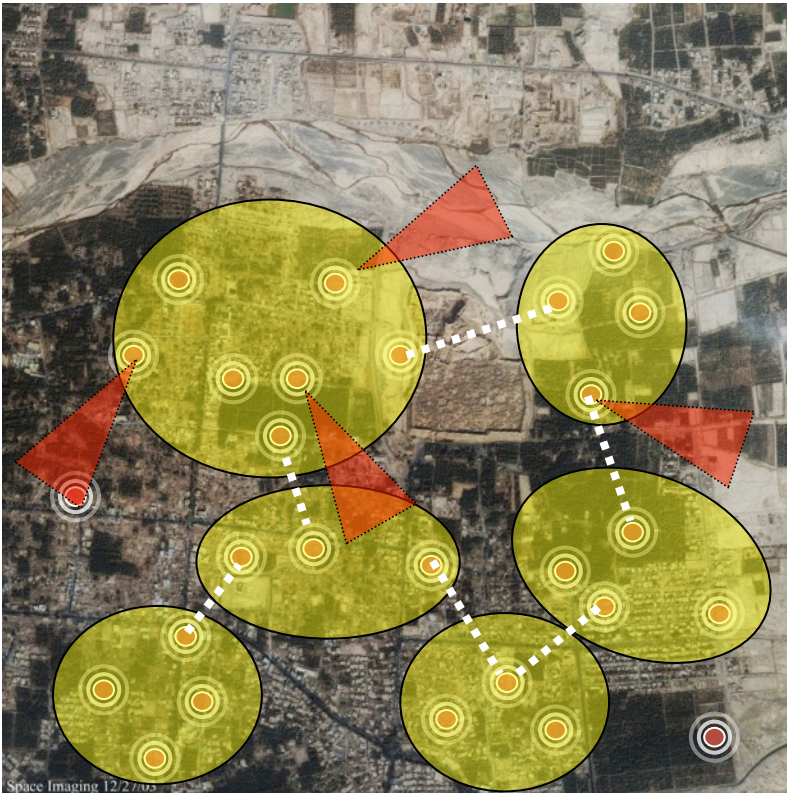
Imote2



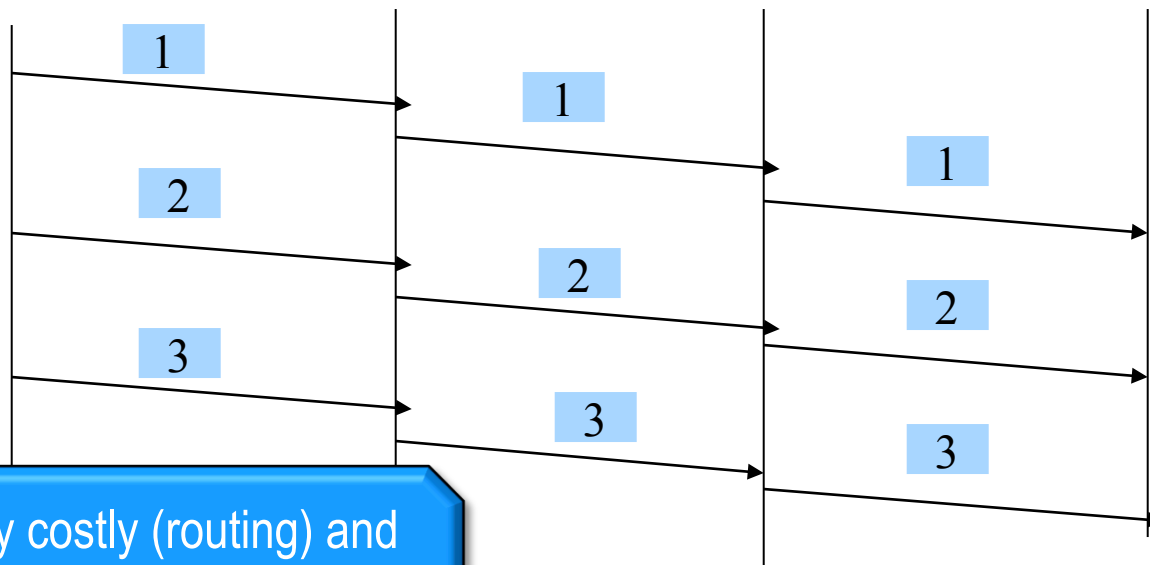
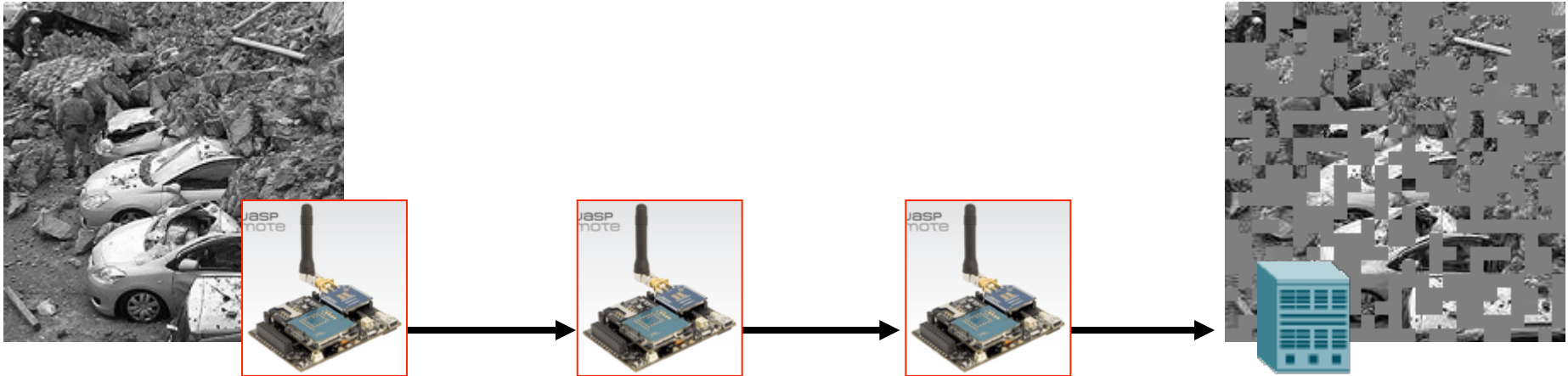
Multimedia board



GET IMAGES FROM DEPLOYED SENSORS



MULTI-HOP PACKET FORWARDING



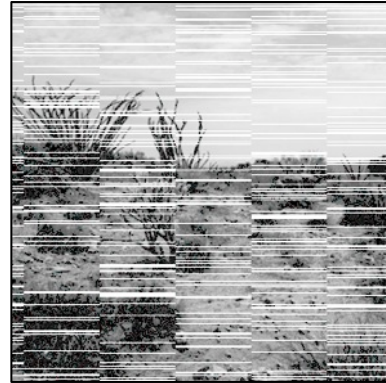
Multi-hop is very costly (routing) and generates lot's of packet losses!

IMAGE QUALITY? UNCOMPRESSED BMP

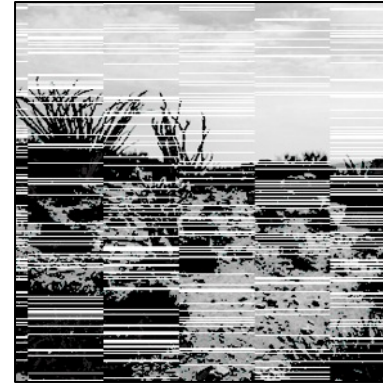
1617 PACKETS, 64 BYTES PAYLOAD, ONE HOP
LOSS RATE: 20%, NO LOSS BURSTS (RADIO), NO DUTY-CYCLING



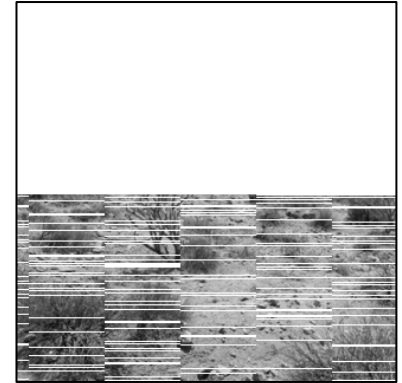
ORIGINAL 320X320
256 GRAY LEVELS,
BMP 102400 BYTES



1340 OUT OF 1617
PACKETS RECEIVED



1303 OUT OF 1617
PACKETS RECEIVED



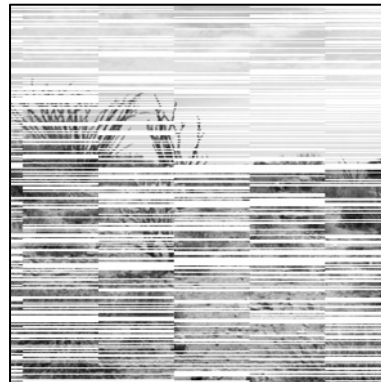
674 OUT OF 1617
PACKETS RECEIVED

MAX TX RATE = 250 KPS
(IEEE 802.15.4)

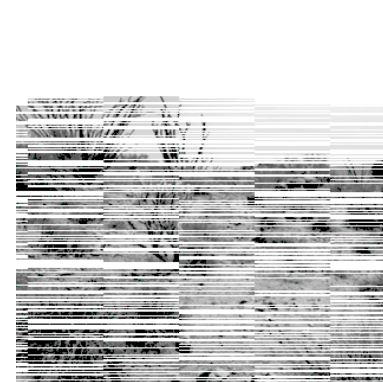
MINIMUM LATENCY = 6.46S

Cannot really use the
compressed version of
BMP using RLE.

WITH LOSS BURSTS (RADIO)



921 OUT OF 1617
PACKETS RECEIVED



689 OUT OF 1617
PACKETS RECEIVED



913 OUT OF 1617
PACKETS RECEIVED

IMAGE QUALITY? STANDARD JPG

427 PACKETS, 64 BYTES PAYLOAD, ONE HOP
LOSS RATE: 20%, NO LOSS BURSTS (RADIO), NO DUTY-CYCLING



ORIGINAL 320X320
256 GRAY LEVELS,
JPG 27303 BYTES

MAX TX RATE = 250 KPS
(IEEE 802.15.4)

MINIMUM LATENCY = 1.61S



348 OUT OF 427
PACKETS RECEIVED



351 OUT OF 427
PACKETS RECEIVED

9 OUT OF 12 IMAGES
COULD NOT BE DECODED



349 OUT OF 1617
PACKETS RECEIVED

WITH LOSS BURSTS (RADIO)



258 OUT OF 427
PACKETS RECEIVED



270 OUT OF 427
PACKETS RECEIVED

8 OUT OF 12 IMAGES
COULD NOT BE DECODED



269 OUT OF 427
PACKETS RECEIVED

Encoding cost of
JPEG2000 is too high for
these devices.

IMPROVING IMAGE ROBUSTNESS

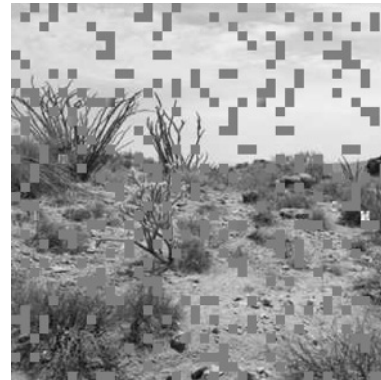
302 PACKETS, 64 BYTES PAYLOAD, ONE HOP
LOSS RATE: 20%, NO LOSS BURSTS (RADIO), NO DUTY-CYCLING



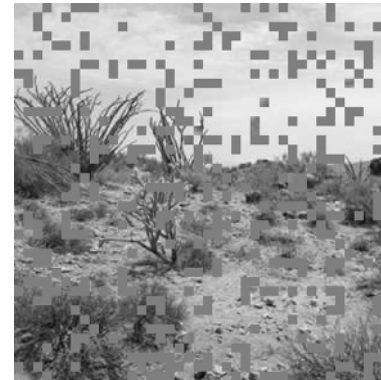
ORIGINAL 320X320
256 GRAY LEVELS,
WSN SPECIFIC 17199 BYTES

MAX TX RATE = 250 KPS
(IEEE 802.15.4)

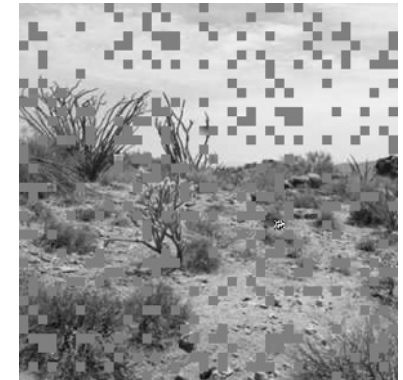
MINIMUM LATENCY = 1.14S



248 OUT OF 302
PACKETS RECEIVED

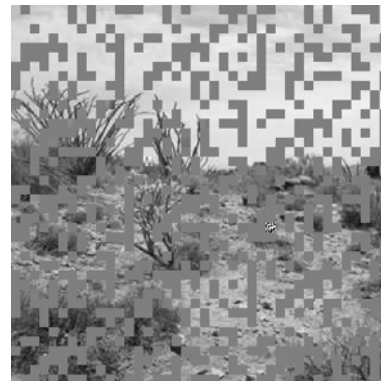


236 OUT OF 302
PACKETS RECEIVED

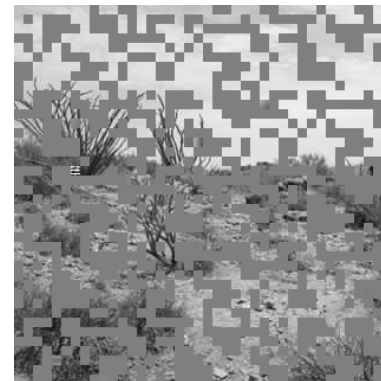


243 OUT OF 302
PACKETS RECEIVED

WITH LOSS BURSTS (RADIO)



188 OUT OF 302
PACKETS RECEIVED



167 OUT OF 302
PACKETS RECEIVED



158 OUT OF 302
PACKETS RECEIVED

Collaboration with CRAN
laboratory, Nancy, France,
for robust image encoding
techniques for WSN.

DYNAMIC QUALITY FACTOR 128x128

Original BMP 16384b Q=50 S=4800b 63pkts Q=40 S=4268b 56pkts Q=30 S=3604b 46pkts



PSNR=24.6765

PSNR=23.4172

PSNR=22.0078

Q=20 S=2781b 34pkts Q=15 S=2268b 28pkts Q=10 S=1757b 12pkts Q=5 S=1006b 12pkts



PSNR=20.4087

PSNR=19.5864

PSNR=18.6861

PSNR=17.3283

DYNAMIC QUALITY FACTOR 200X200

Original BMP 40000b

Q=50 S=11045b 142pkts

Q=40 S=9701b 123pkts

Q=30 S=8100b 101pkts



PSNR=25.1661



PSNR=24.2231



PSNR=23.2264

Q=20 S=6236b 76pkts

Q=15 S=5188b 63pkts

Q=10 S=3868b 47pkts

Q=5 S=2053b 24pkts



PSNR=22.1293



PSNR=21.4475

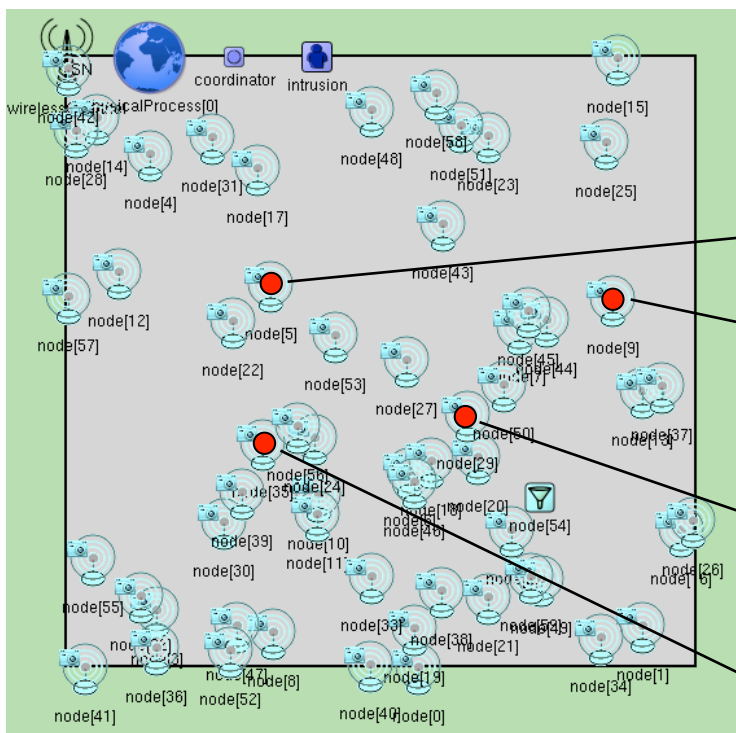


PSNR=20.5255



PSNR=18.937

SIMULATIONS



60 IMAGE SENSOR NODES
75MX75M
1 SINK (NODE 54)

Application:Image sent

	Images	Packets	by coverset
node=2	1	206	0
node=5	4	824	0
node=9	2	412	2
node=10	6	1236	6
node=12	1	206	0
node=15	2	412	2
node=17	1	206	0
node=19	3	618	0
node=22	4	824	0
node=23	2	412	0
node=24	6	1236	0
node=26	1	206	1
node=27	6	1236	0
node=29	7	1442	6
node=33	6	1236	6
node=35	12	2472	0
node=37	5	1030	0
node=40	8	1648	3
node=46	2	412	2
node=48	2	412	0
node=50	2	412	2

Application:Image displayed

	all	complete	truncated
index=-1	39	21	18
index=5	1	0	1
index=9	2	1	1
index=10	6	3	3
index=23	2	0	2
index=24	3	0	3
index=27	4	4	0
index=29	7	6	1
index=33	3	3	0
index=35	4	0	4
index=37	5	3	2
index=50	2	1	1

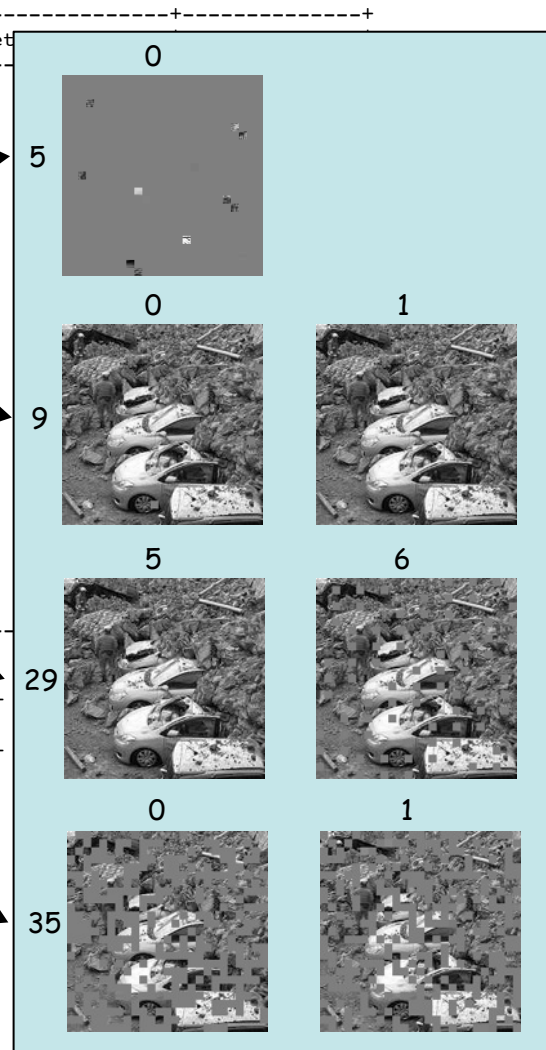
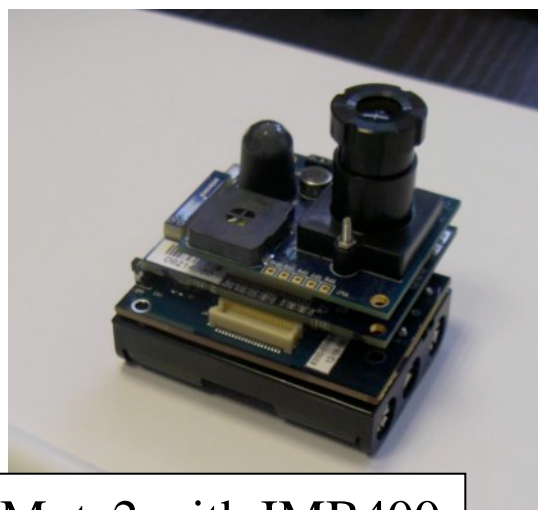


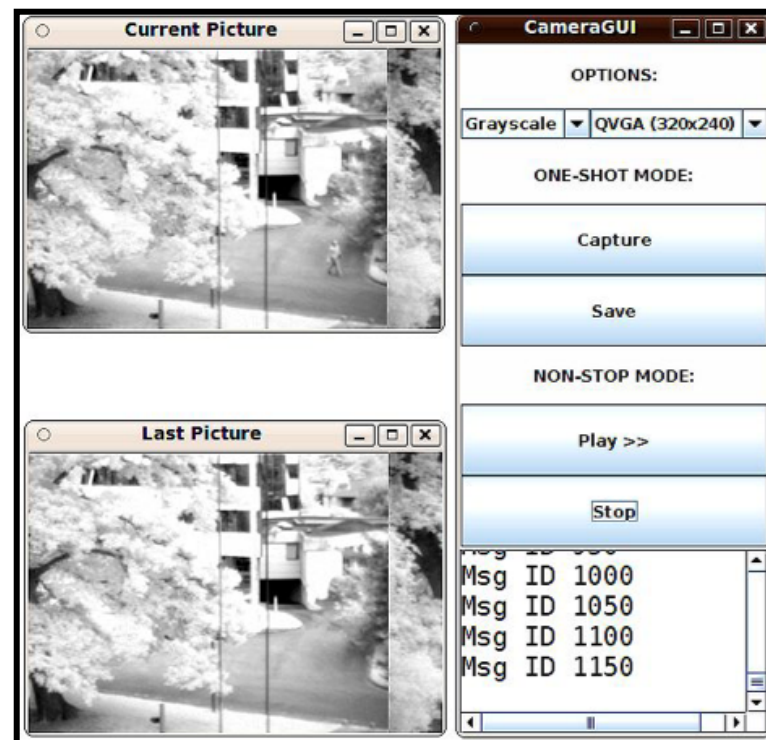
IMAGE SENSOR MOTES



iMote2



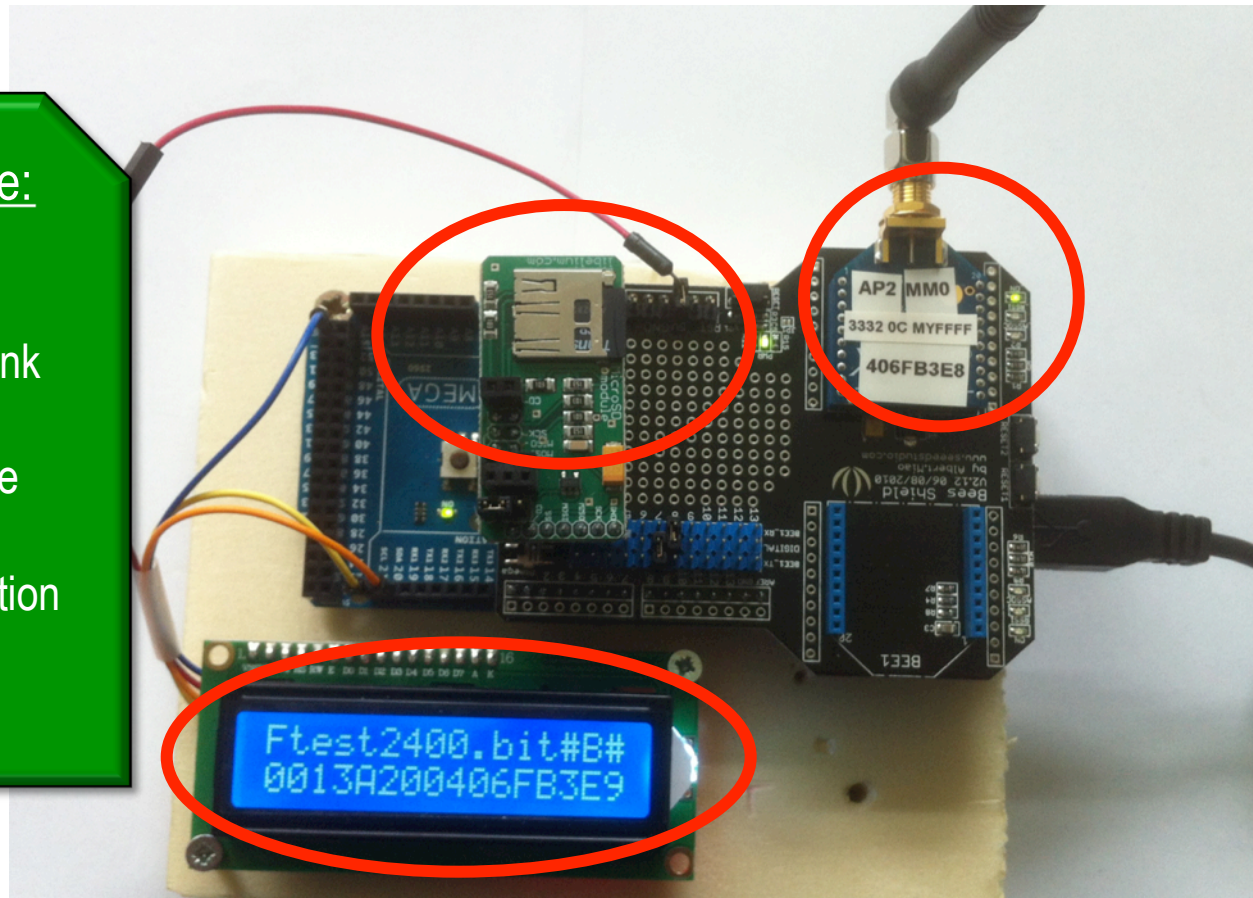
iMote2 with IMB400 multimedia board



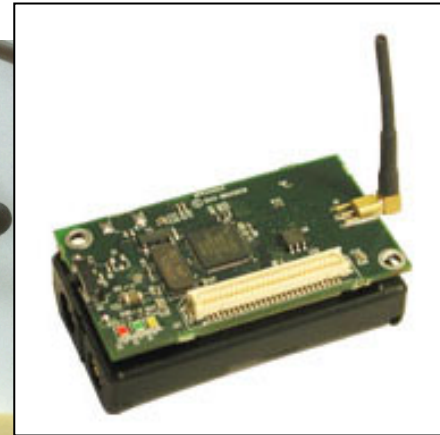
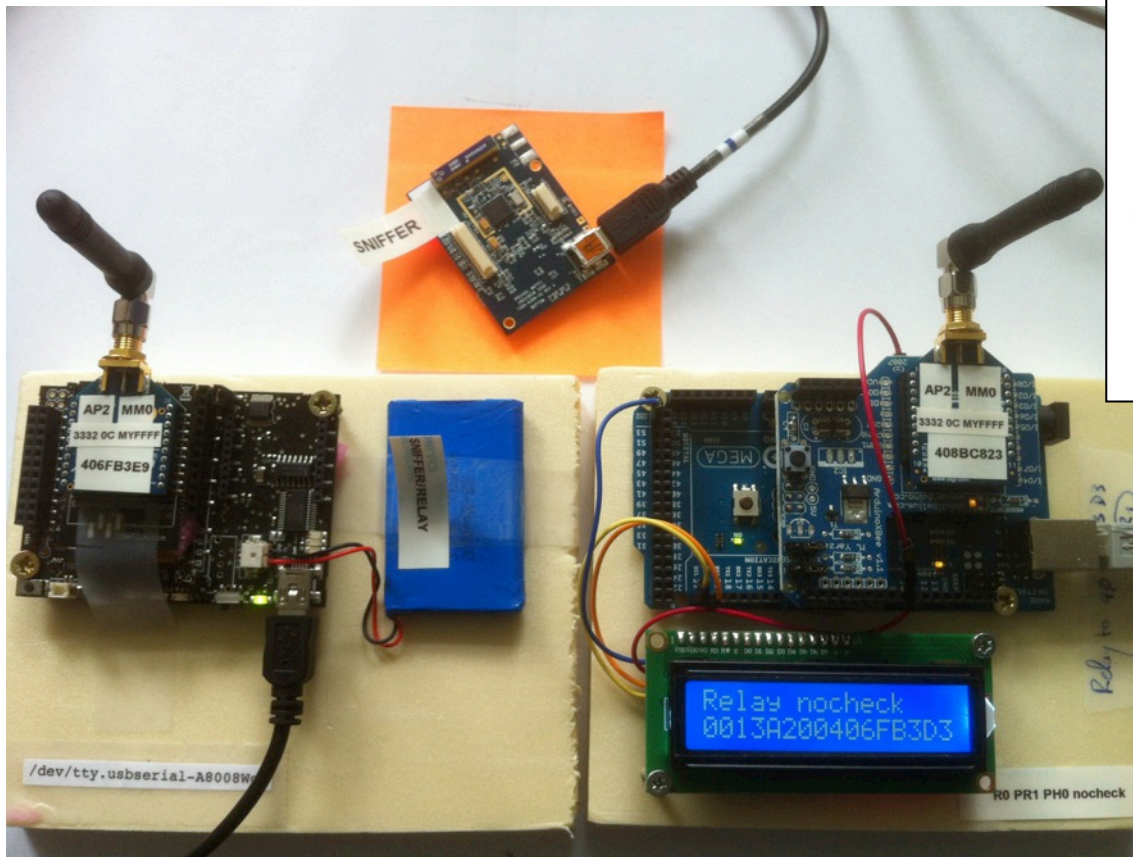
MORE GENERIC SOLUTION: FILE SENDER NODE

Fully configurable:

File to send
Size of packet chunk
Inter-packet delay
Image/Binary mode
Destination node
Clock synchronization



RELAY NODES

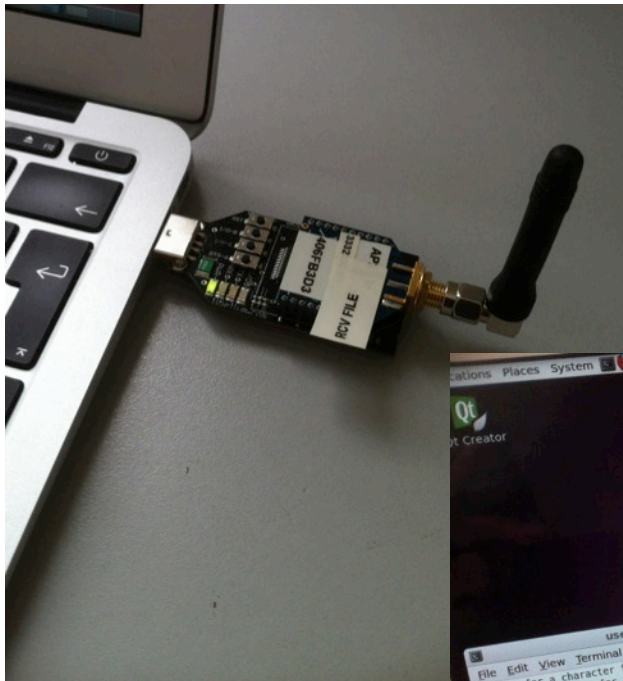


Fully configurable:

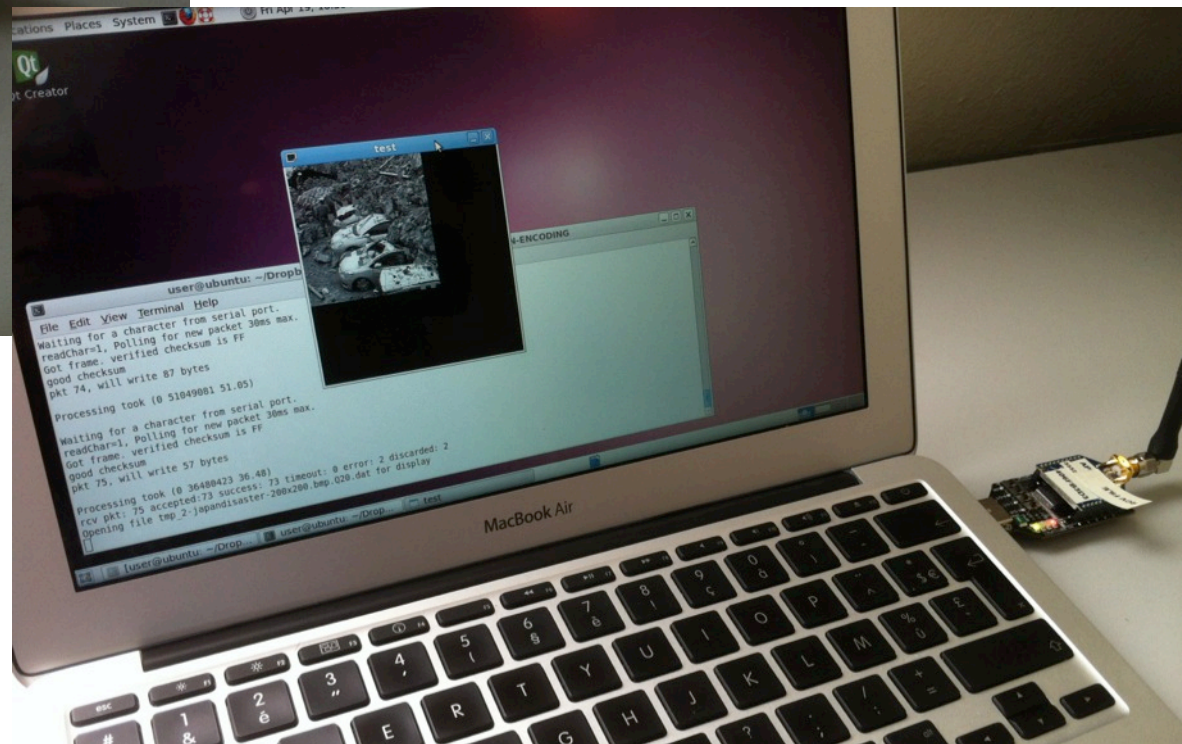
Destination node
Additional relay delay
Clock synchronization

LIBELIUM WASPMOTE, IMOTE2, ARDUINO, TELOS B, MICA Z

SINK NODE



LINUX PC/LAPTOP WITH
USB/SERIAL GATEWAY

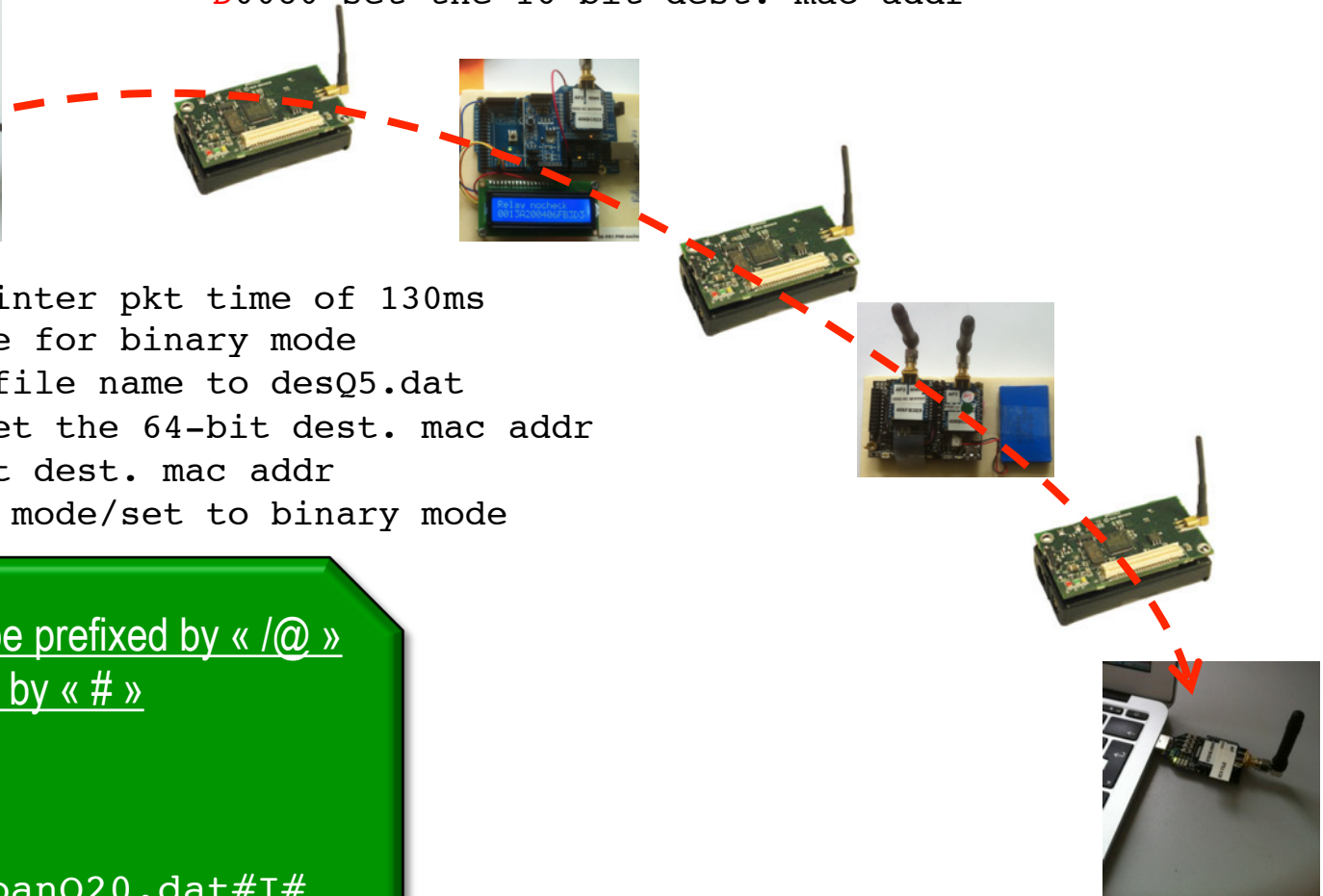
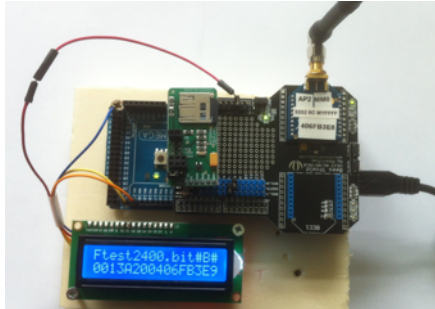


MOTIVATIONS

- ❑ NEED A CONTROLLED ENVIRONMENT TO
 - ❑ TEST MULTI-SOURCE SCENARIO
 - ❑ QUANTIFY IMPACT OF RADIO INTERFERENCE
 - ❑ TEST MULTI-PATH ROUTING AND BUFFER MANAGEMENT FOR CONGESTION CONTROL
 - ❑ KNOW TYPICAL LATENCIES
- ❑ ADOPT A « FULLY CONTROLLABLE » APPROACH
 - ❑ EACH NODE CAN BE DYNAMICALLY CONFIGURED...
 - ❑ ... TO « KNOW » WHAT IS GOING ON.

MOTE NODES

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



T130 transmit with inter pkt time of 130ms
Z50 set the pkt size for binary mode
FdesQ5.dat set the file name to desQ5.dat
D0013A2004086D828 set the 64-bit dest. mac addr
D0080 set the 16-bit dest. mac addr
I or B set to image mode/set to binary mode

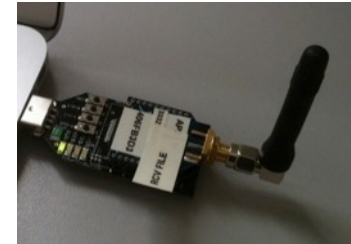
All commands must be prefixed by « /@ »
and ended/separated by « # »

Examples:

/@T130#, /@FjapanQ20.dat#I#

XBeeReceive Unix tool

XBEESENDCMD



❑ XBEESENDCMD

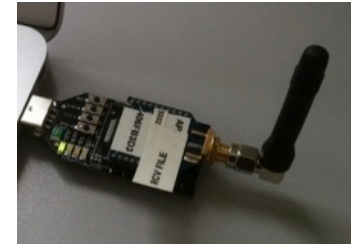
- ❑ USES AN XBEE GATEWAY TO SEND ASCII STRING COMMAND, E.G. « **/@D0030#** »

```
USAGE: ./XBeeSendCmd -p dev [-A][-DM][-at] -tinyos -tinyos_amid id_hex -mac|-net|-addr|-b message
USAGE: -p /dev/ttyUSB1
USAGE: -mac 0013a2004069165d HELLO
USAGE: -net 5678 HELLO
USAGE: -addr 64_or_16_bit_addr HELLO
USAGE: -b HELLO
USAGE: -at to send remote AT command: -at -mac 0013a2004069165d ATMM
USAGE: -A to avoid insertion of Libelium API header, for pure Arduino for instance
USAGE: -DM to specify DigiMesh firmware
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)
```

❑ EXAMPLE:

- ❑ XBeeSendCmd `—addr 0013A2004086D835 hello`
- ❑ XBeeSendCmd `—addr 0013A2004086D835 /@z50#`

XBEE RECEIVE

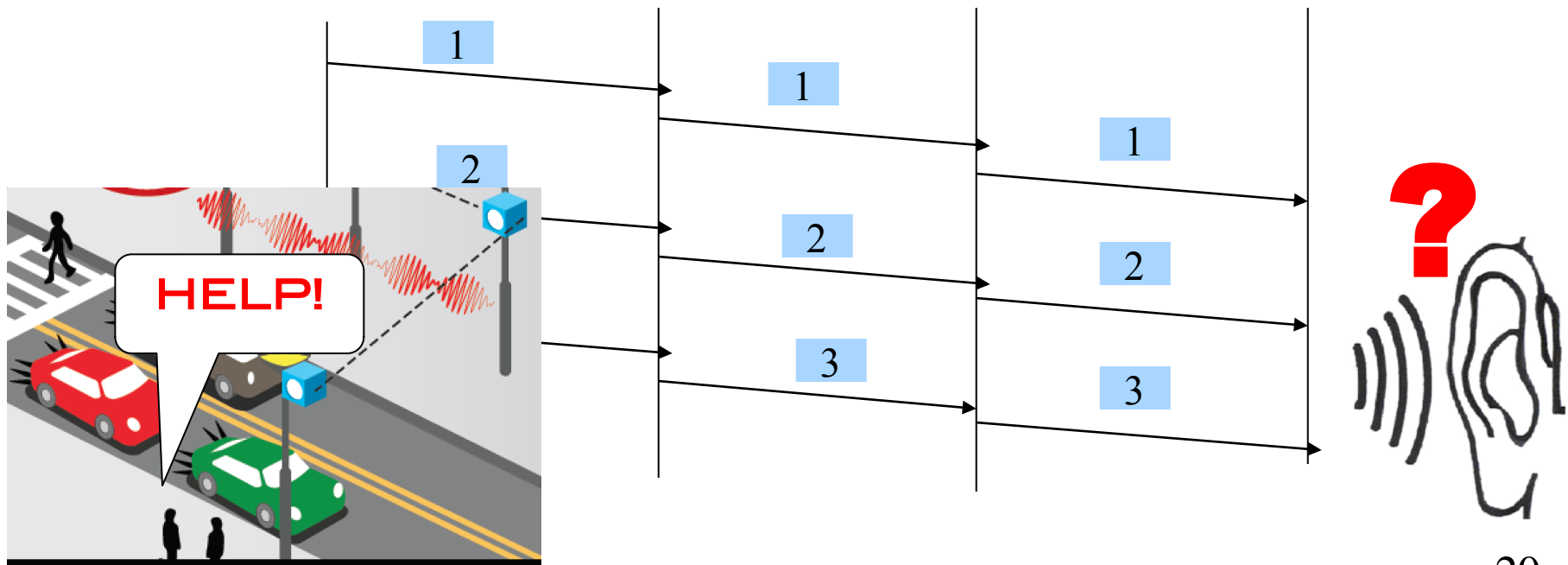
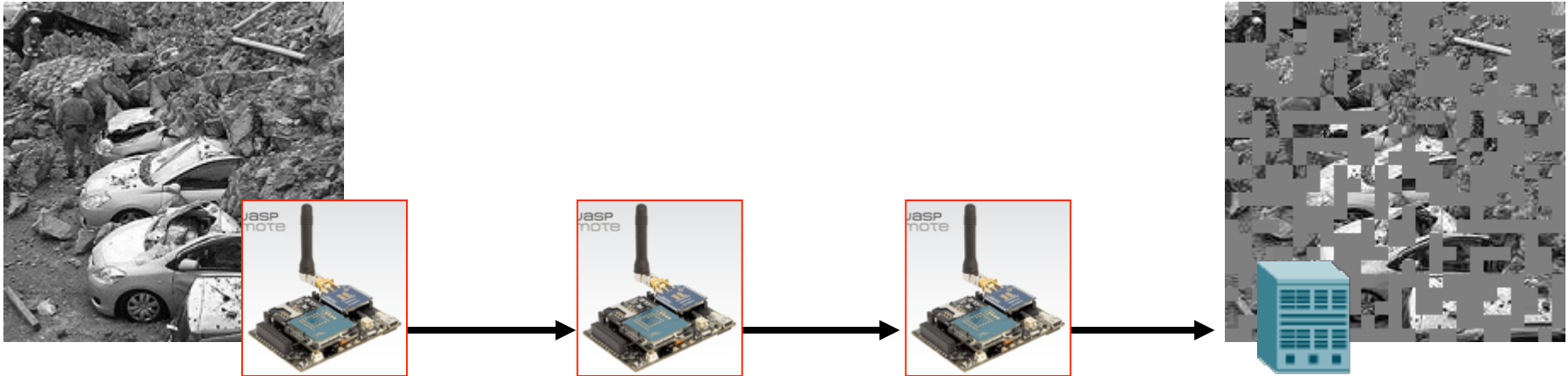


❑ XBEE RECEIVE

- ❑ USES AN XBEE GATEWAY
- ❑ READ FROM THE SERIAL PORT
 - /dev/ttyUSB0, /dev/ttyS0, ...
- ❑ DISPLAY IMAGES IN IMAGE MODE
- ❑ RECONSTRUCT FILE IN BINARY MODE
- ❑ CAN WRITE TO STDOUT

```
USAGE: ./XBeeReceive -baud b -p dev -onlydisplay img_file.dat -pktd -pktf -B/-I -ap0 -v val
        -stdout -Q 40 file_name
USAGE: -baud, set baud rate, default is 38400
USAGE: -p /dev/ttyUSB1
USAGE: -onlydisplay img_file.dat, display the .dat file only
USAGE: -pktd, display received XBee frames
USAGE: -pktf, generate pkt list file
USAGE: -B/-I, -B for binary mode, -I for image mode, default is image mode
USAGE: -ap0, indicates an Xbee in AP mode 0 (transparent mode) so do not decode frame structure
USAGE: -v 77, use 0x77 to fill in missing value in binary mode
USAGE: -stdout, write to stdout for pipe mode, don't work with image mode
USAGE: -Q 40, use 40 as Quality Factor, default is 50
USAGE: file_name, for images: give the original bmp file. for binary: give any file name
```

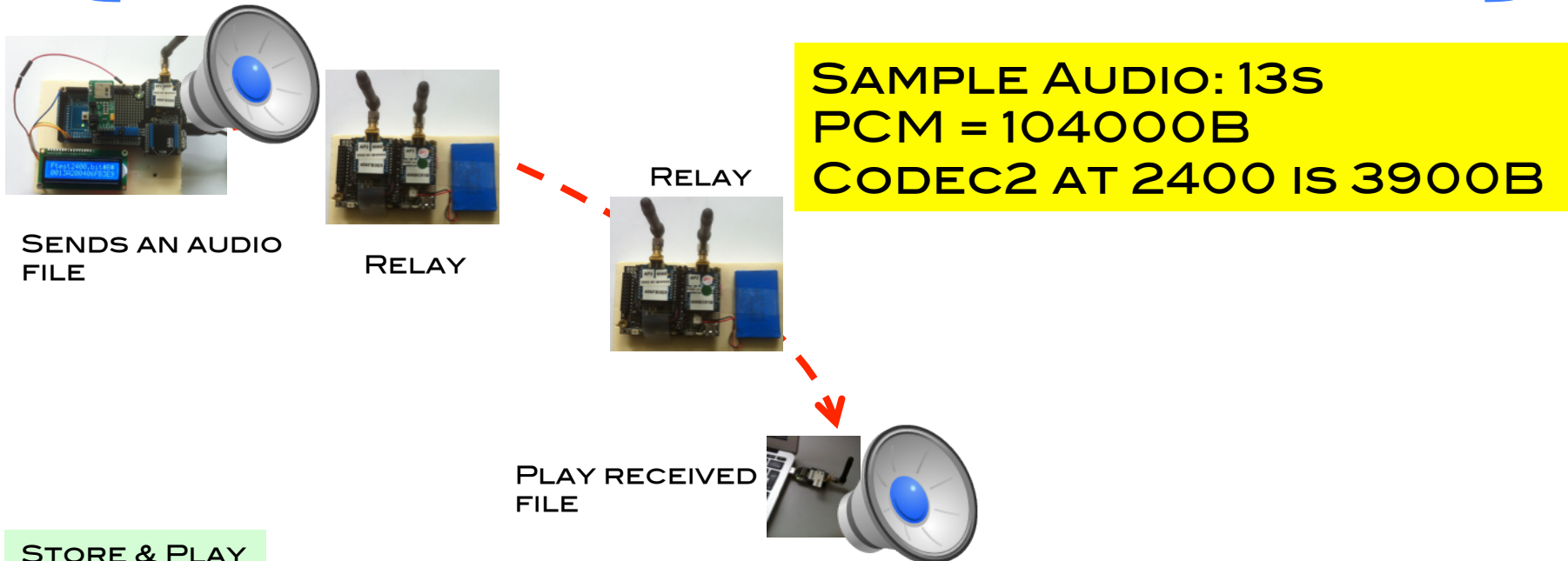
MULTI-HOP PACKET FORWARDING?



FROM EAR-IT PROJECT

AUDIO DATA STREAMING

EXAMPLE OF stdout USAGE



STORE & PLAY

```
> XBeeReceive -B test2400.bit  
> c2dec 2400 -B test2400.bit - | play -t raw -r 8000 -s -2 -
```

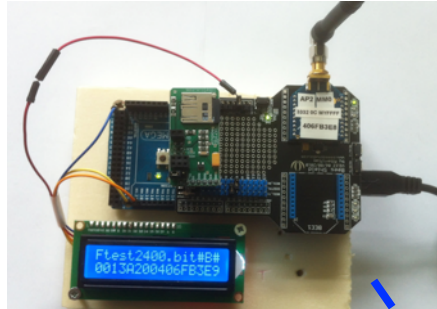
STREAMING

```
> XBeeReceive -B -stdout test2400.bit | bfr -b1k -m2% - | c2dec  
2400 - - | play --buffer 50 -t raw -r 8000 -s -2 -
```

NOW DEMO TIME!

IMAGE DEMO

0x0013A20040762191



Q=20 S=6236b 76pkts



- > XBeeSendCmd -A -addr 0013A20040762191 /@FjapanQ20.dat#I#
- XBeeSendCmd -A -addr 0013A20040762191 /@D0030
- XBeeSendCmd -A -addr 0030 /@D0060
- XBeeSendCmd -A -addr 0060 /@D0013A2004086D835
- XBeeSendCmd -A -addr 0013A20040762191 /@T90#

0x0030

0x0060

0x0013A2004086D835

0x0070

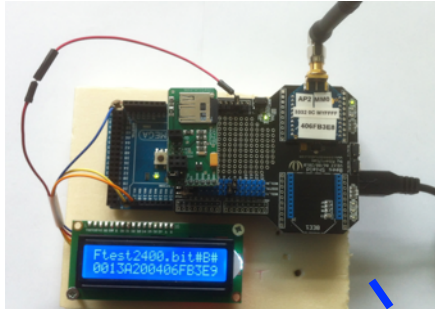
- > XBeeSendCmd -A -addr 0013A20040762191 /@D0070
- XBeeSendCmd -A -addr 0070 /@D0013A2004086D835
- XBeeSendCmd -A -addr 0013A20040762191 /@T90#

XBeeReceive Unix tool

- XBeeReceive -I -Q 20 japandisaster-200x200.bmp

IMAGE DEMO

0x0013A20040762191



Q=20 S=6236b 76pkts



0x0030



0x0060



0x0070

0x0013A2004086D835

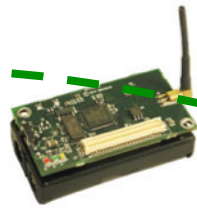
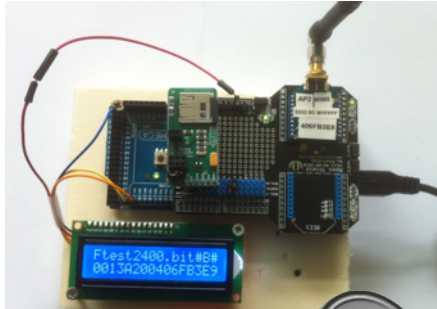


- > XBeeSendCmd -A -addr 0013A20040762191 /@D0030
- > XBeeSendCmd -A -addr 0060 /@D0070
- > XBeeSendCmd -A -addr 0013A20040762191 /@T90#

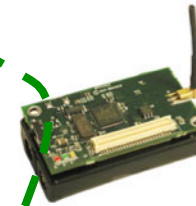
XBeeReceive Unix tool

AUDIO STREAMING DEMO

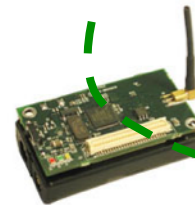
0x0013A20040762191



0x0030



0x0060



0x0070

0x0013A200408D835



- XBeeSendCmd -A -addr 0013A20040762191 /@Ftest2400.dat#B#
- XBeeSendCmd -A -addr 0013A20040762191 /@T90#

- XBeeReceive -B -stdout test2400.bit | bfr -blk -m2% - | c2dec 2400 - -
| play --buffer 50 -t raw -r 8000 -s -2 -

XBeeReceive Unix tool