Communicating Objects & Sensor Networks

LIRE laboratory
Univ. Constantine
January 21st, 2014, Algeria

Prof. Congduc Pham
http://www.univ-pau.fr/~cpham
Université de Pau, France

Objets Communicants et Réseaux de capteurs

Introduction et présentations de nos travaux sur l'image et l'audio

Laboratoire LIRE
Univ. Constantine
21 janvier 2014, Algérie

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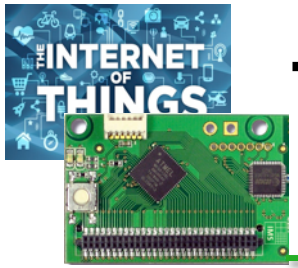
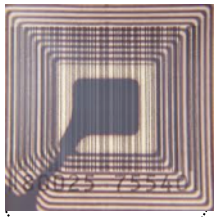
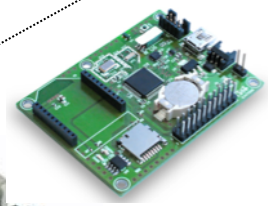


Towards small, smart devices!



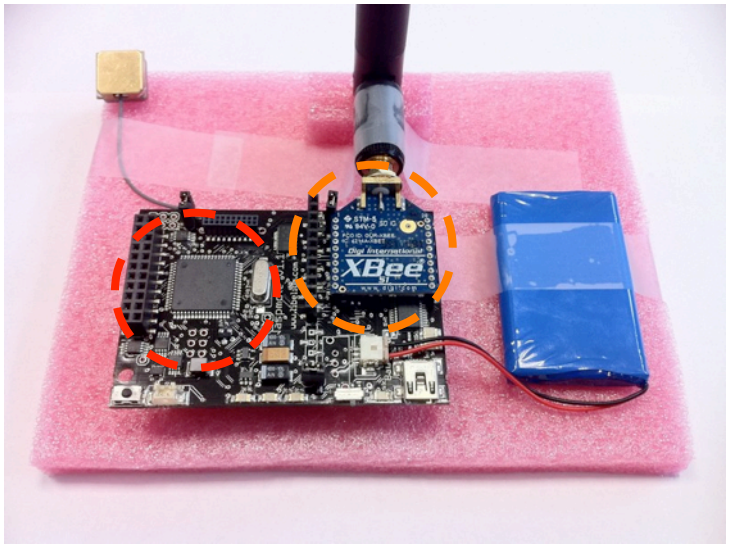


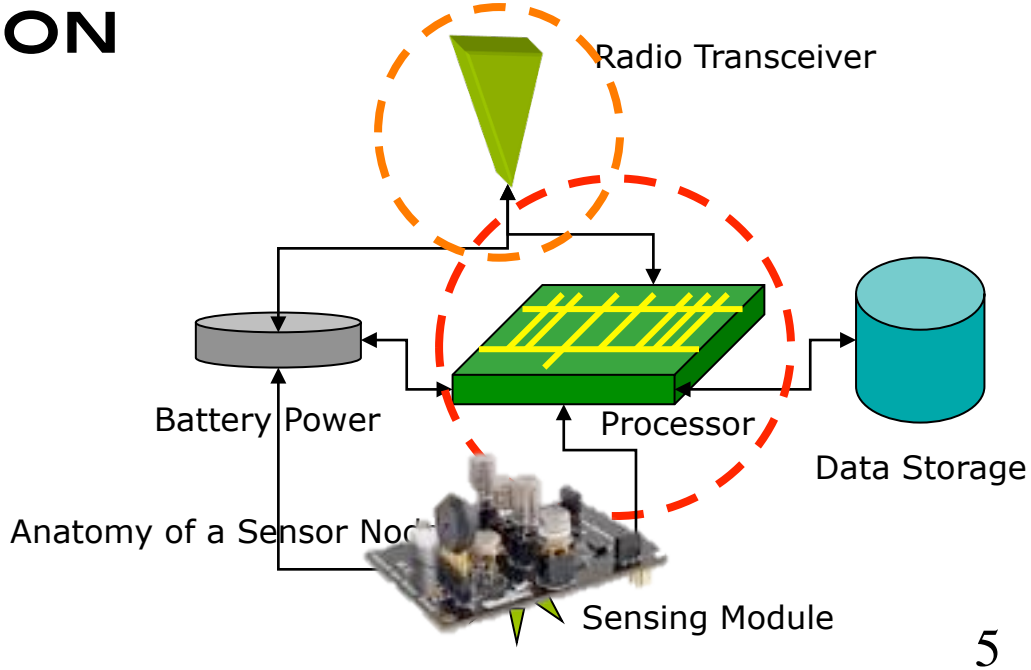


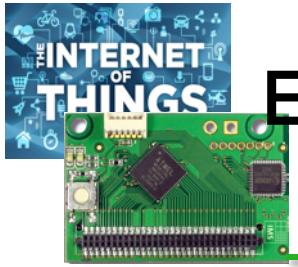



Wireless autonomous sensor

- In general: low cost, low power (the battery may not be replaceable), small size, prone to failure, possibly disposable
- Role: sensing, **data processing**, communication







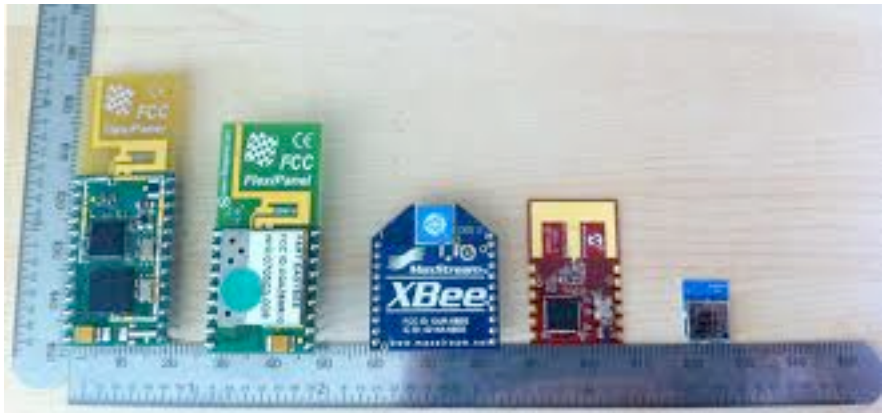
Beyond Sensor Networks: Communicating Objects!

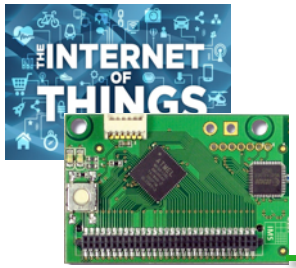
- Native communication:

- Added communication
  - Active communication

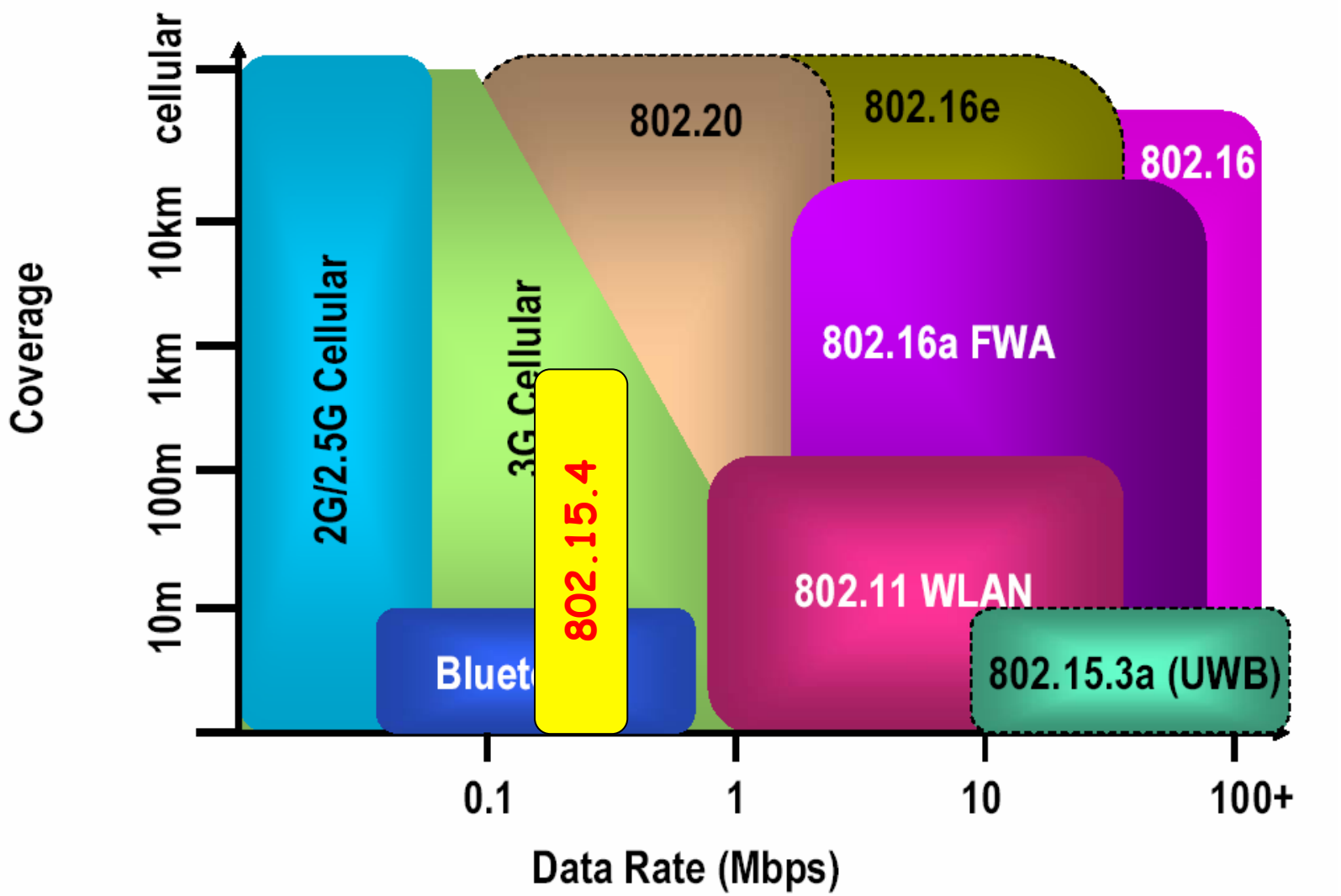
- Passive communication

Wireless Communication made easy

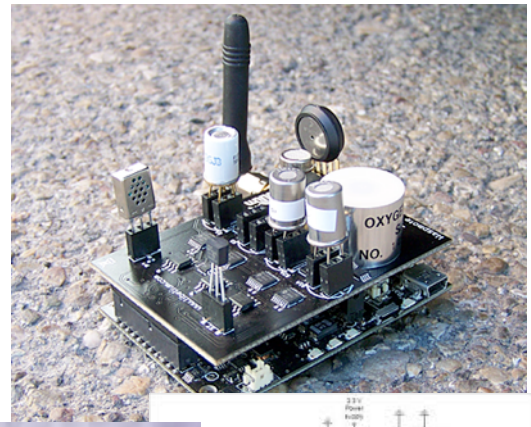




Wireless technologies



Energy consideration



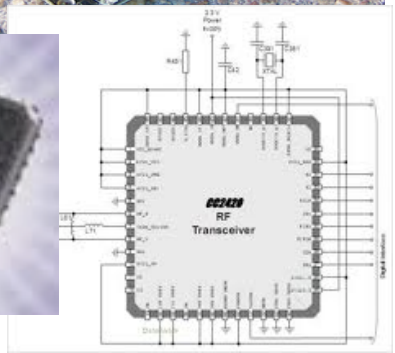
18720 Joules

TX power 0dbm: 17.4mA

P = I x V = 17.4 x 3.3 = 57.42mW

E = P x t -> t = E/P

326018s or 90.5h



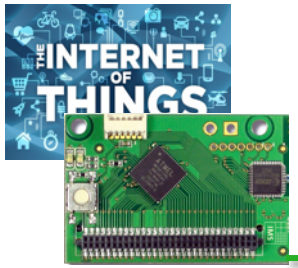
Chipcon Products from Texas Instruments

CC2420

Parameter	Min.	Typ.	Max.	Unit	Condition / Note
Current Consumption, transmit mode:					
P = -25 dBm		8.5		mA	The output power is delivered differentially to a 50 Ω singled ended load through a balun, see also page 55.
P = -15 dBm		9.9		mA	
P = -10 dBm		11		mA	
P = –5 dBm		14		mA	
P = 0 dBm		17.4		mA	

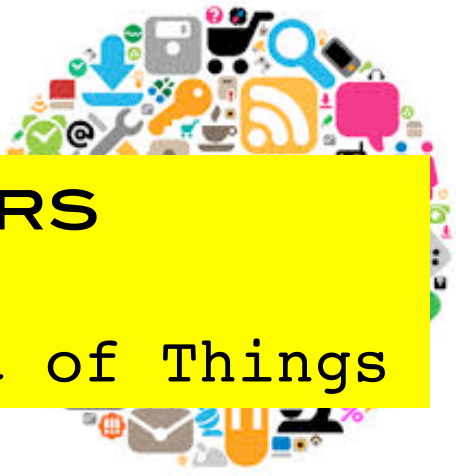
Haven't considered:

- Baseline power consumption of the sensor board
- RX consumption: 18.8mA!
- Event capture consumption
- Event processing consumption



Internet of Things

- Many new terms for quite old concepts!
  - Internet 0
  - Internet of Things

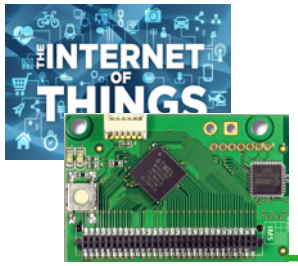


The I-o-T for beginners

http://readwrite.com/tag/Internet of Things

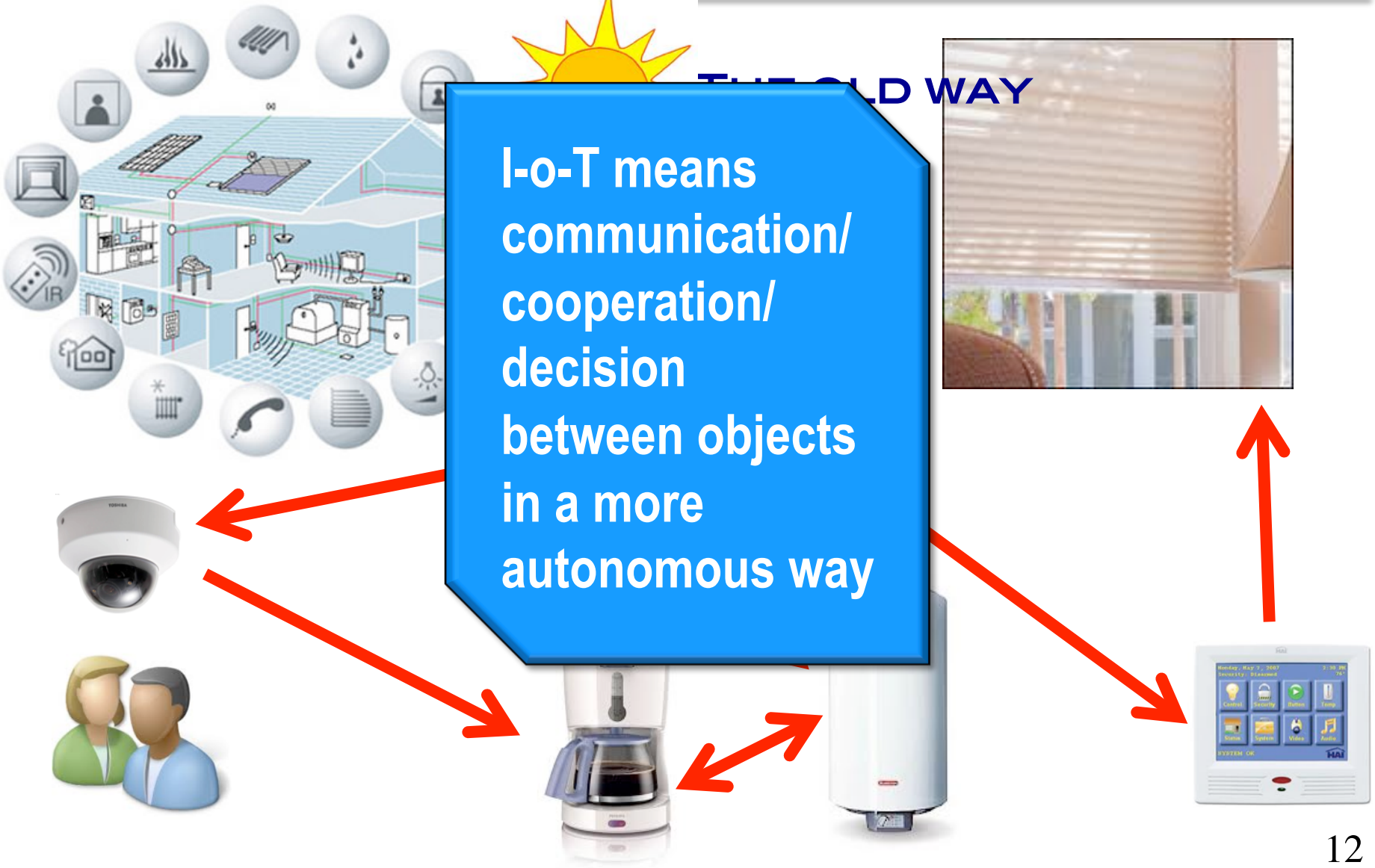
  - D2D: Device-to-Device

- Motivations are
  - Situation/Context awareness
  - Ubiquitous sensing/computing
  - More « intelligence » into machines

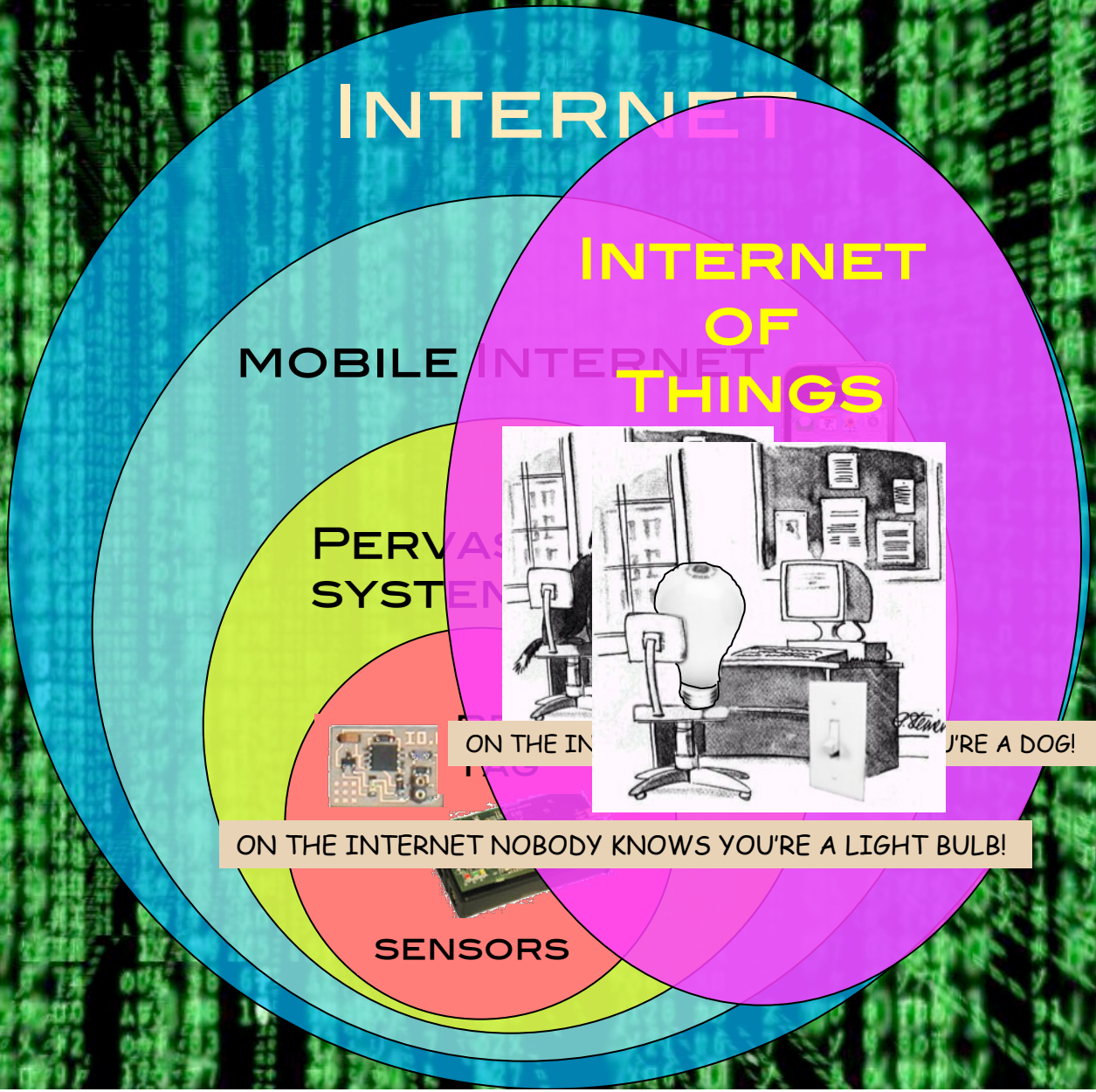


WHAT'S NEW?

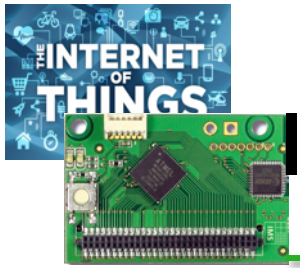
WHAT'S NEW?


THE OLD WAY
I-o-T means communication/ cooperation/ decision between objects in a more autonomous way

Digital Wireless World

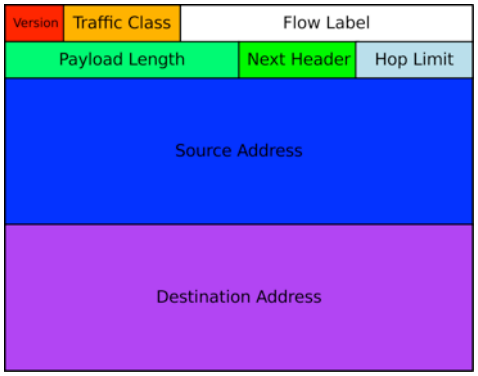


FROM « AD-HOC » PROTOCOLS TO « STANDARDS »

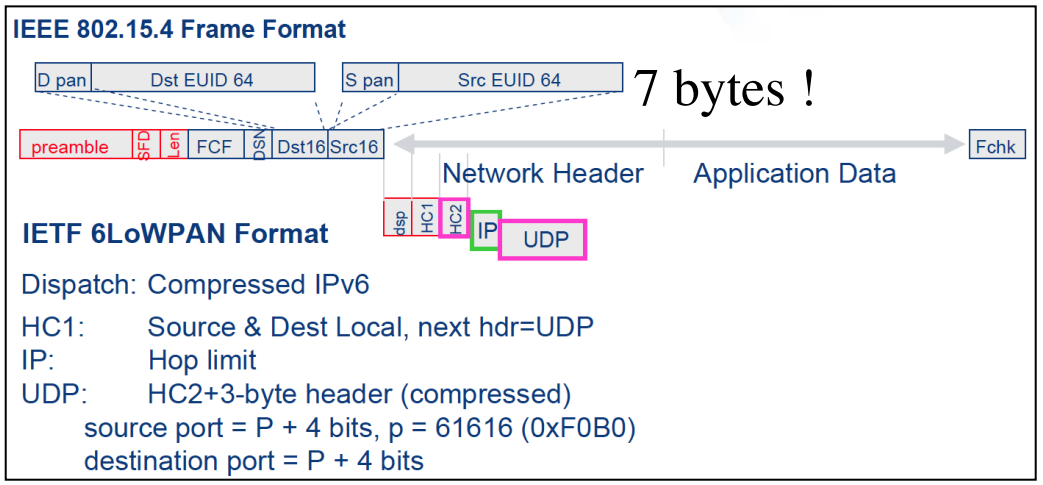


Internet of Things: IoT

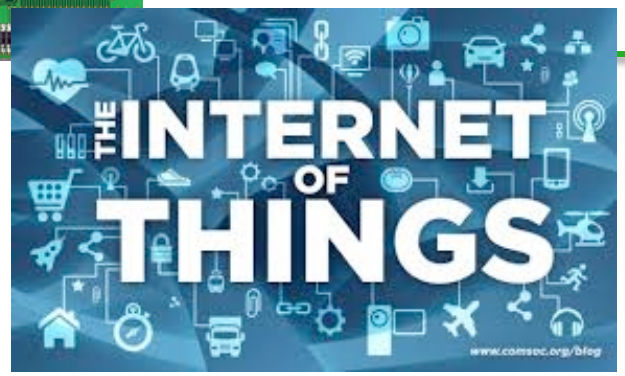
- IPv4 has no more addresses!
- IPv6 gives plenty of addresses
  - 128bit address=16bytes!
- 6LowPan adapts IPv6 to resource-constrained devices
  - Compressed IPv6 header



40 bytes



6LowPan protocol suite



Don't reinvent the wheel!

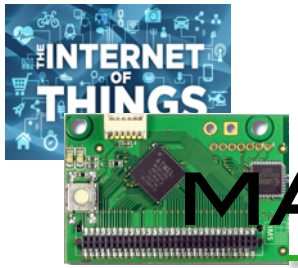
RFC 768	UDP - User Datagram Protocol	[1980]
RFC 791	IPv4 – Internet Protocol	[1981]
RFC 792	ICMPv4 – Internet Control Message Protocol	[1981]
RFC 793	TCP – Transmission Control Protocol	[1981]
RFC 862	Echo Protocol	[1983]
RFC 1101	DNS Encoding of Network Names and Other Types	[1989]
RFC 1191	IPv4 Path MTU Discovery	[1990]
RFC 1981	IPv6 Path MTU Discovery	[1996]
RFC 2131	DHCPv4 - Dynamic Host Configuration Protocol	[1997]
RFC 2375	IPv6 Multicast Address Assignments	[1998]
RFC 2460	IPv6	[1998]
RFC 2765	Stateless IP/ICMP Translation Algorithm (SIIT)	[2000]
RFC 3068	An Anycast Prefix for 6to4 Relay Routers	[2001]
RFC 3307	Allocation Guidelines for IPv6 Multicast Addresses	[2002]
RFC 3315	DHCPv6 - Dynamic Host Configuration Protocol for IPv6	[2003]
RFC 3484	Default Address Selection for IPv6	[2003]
RFC 3587	IPv6 Global Unicast Address Format	[2003]
RFC 3819	Advice for Internet Subnetwork Designers	[2004]
RFC 4007	IPv6 Scoped Address Architecture	[2005]
RFC 4193	Unique Local IPv6 Unicast Addresses	[2005]
RFC 4291	IPv6 Addressing Architecture	[2006]
RFC 4443	ICMPv6 - Internet Control Message Protocol for IPv6	[2006]
RFC 4861	Neighbor Discovery for IP version 6	[2007]
RFC 4944	Transmission of IPv6 Packets over IEEE 802.15.4 Networks	[2007]

From ArchRock "6LowPan tutorial"

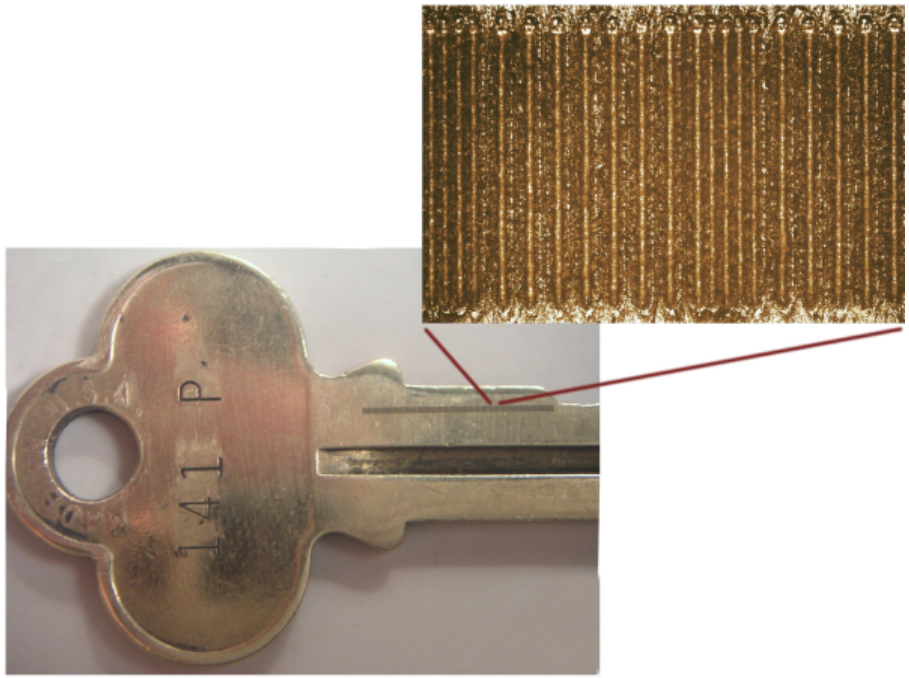
CoAP
Constrained Application Protocol

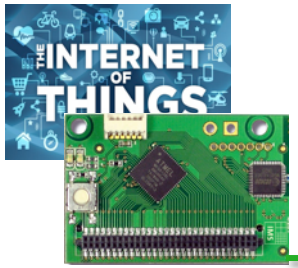
RPL
Routing Protocol for LLN
LLN: Low power & Lossy Networks

6LowPan
802.15.4



Interaction can takes many (unexpected) forms!

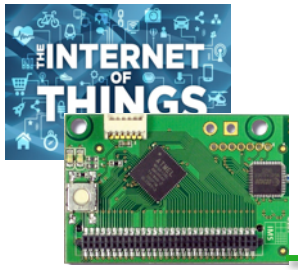




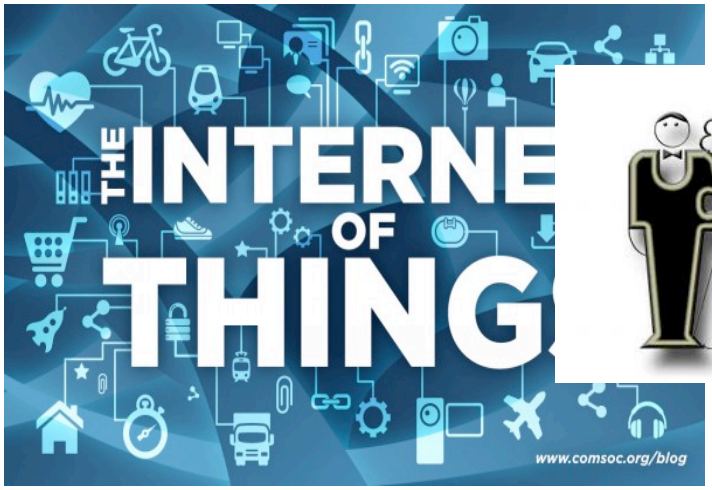
Are you I-o-T or WSN?

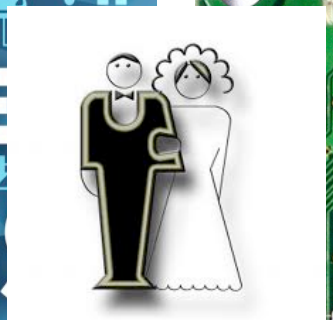
IP integration, WWW
IPv6
Inter-operability
Interactions (all kind)
Semantic, Ontology
Data representation
Data logging
WebServices

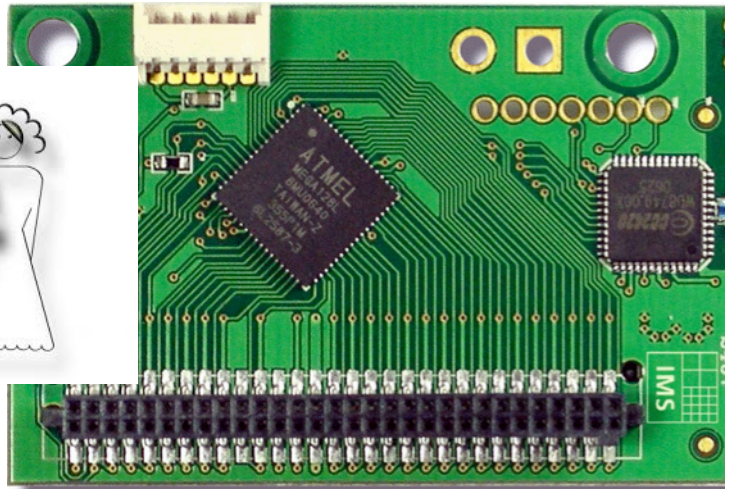
Organization
Programmability
Energy saving
Scheduling
Efficient MAC, routing
Congestion control
Data transmission



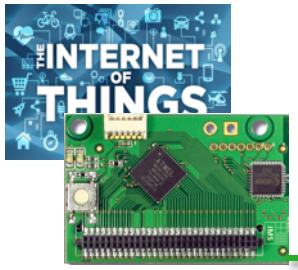
Where is the future?





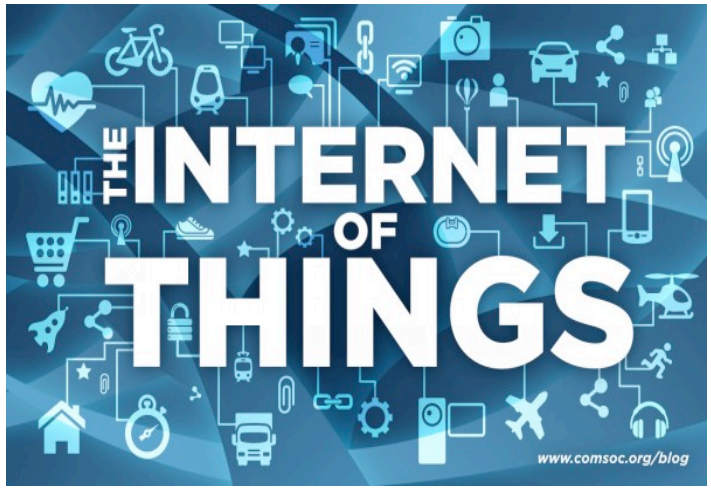


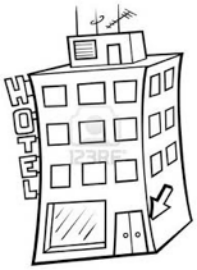
OR ...?



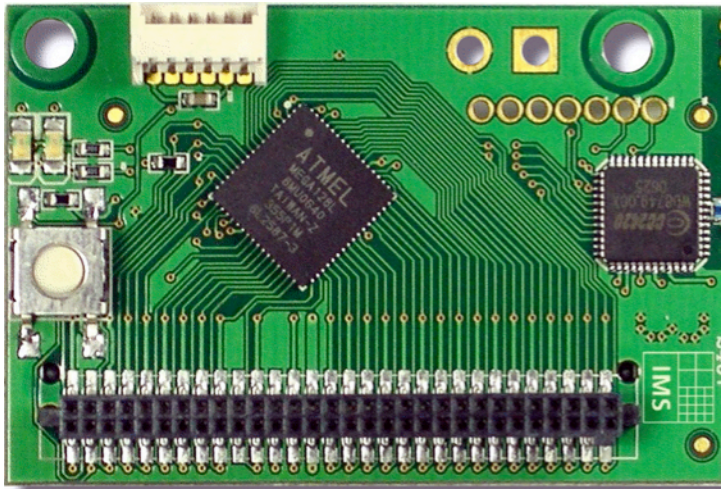
Where is the future?

HOME Sweet HOME

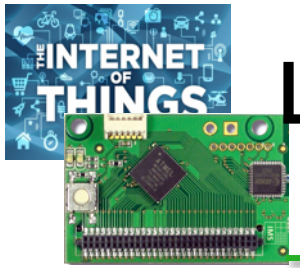




HOME Sweet HOME

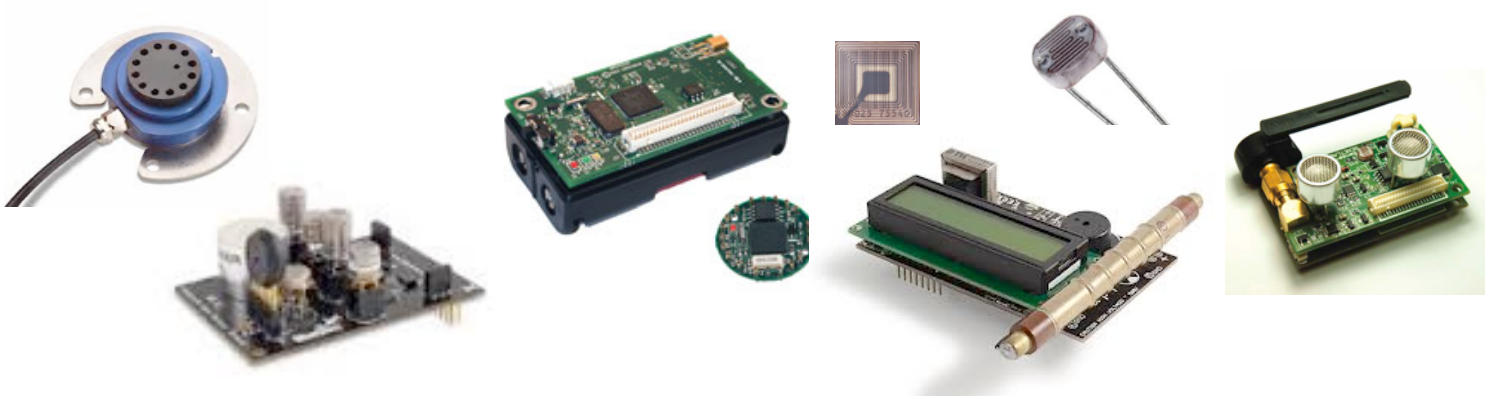


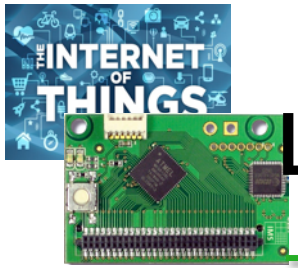
Enjoy my own home but can meet at some occasion



Level 0: measuring the physical world

Sensing

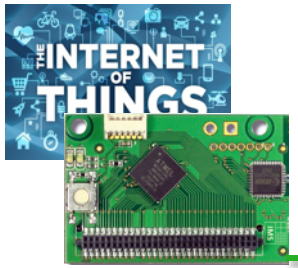




Level 1: Store, Process

Pervasive Systems

Sensing

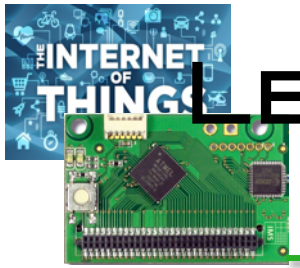


Level 3: connect, interact

Pervasive Systems

Sensing

PEOPLES, INFRASTRUCTURES, BUILDINGS, VEHICULES,...



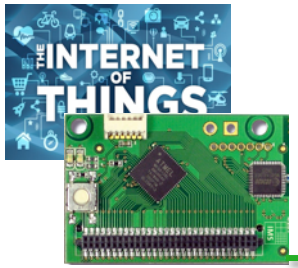
LEVEL 4: CONTROL, OPTIMIZE & INSTRUMENT !

DATA ANALYSIS, OPTIMIZATION & CONTROL

PERVASIVE SYSTEMS

SENSING

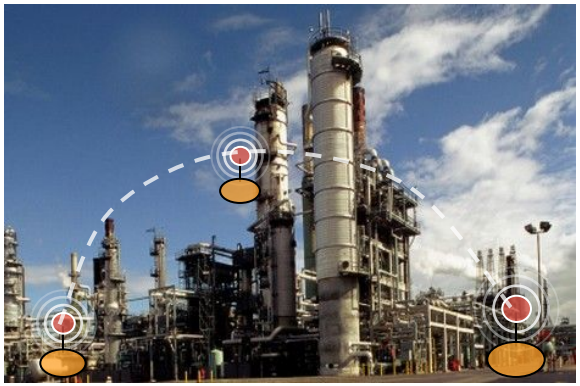
PEOPLES, INFRASTRUCTURES, BUILDINGS, VEHICULES

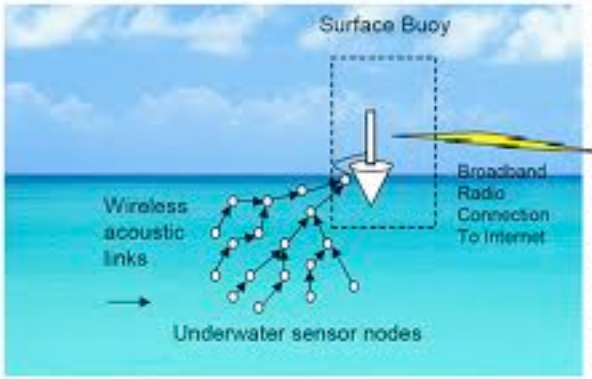


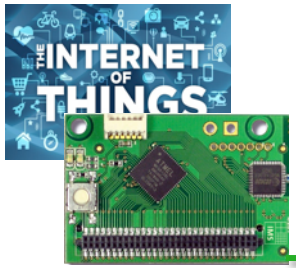
Be Smart* !

- Smart…
  - City, Building, Road, Traffic
  - Agriculture
  - Farming
  - Environment: Water, Forest
  - Energy, Electricity Grid
  - Vehicule & Transportation
  - Transport & Logistic
  - Surveillance, security, safety
  - …

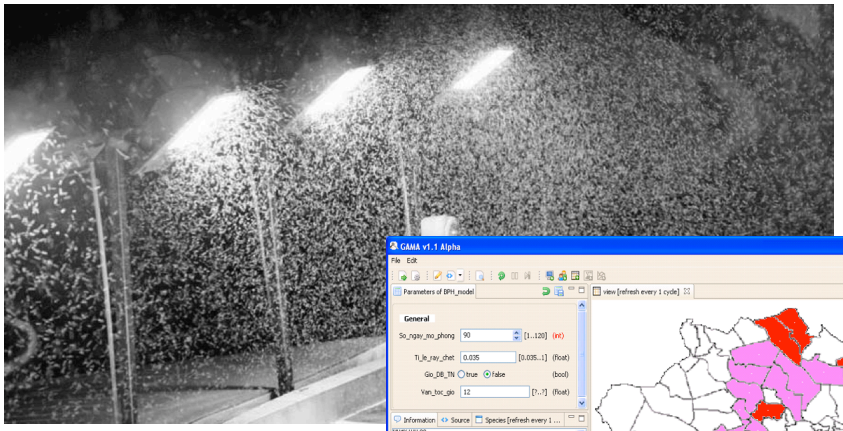
Monitoring/Surveillance

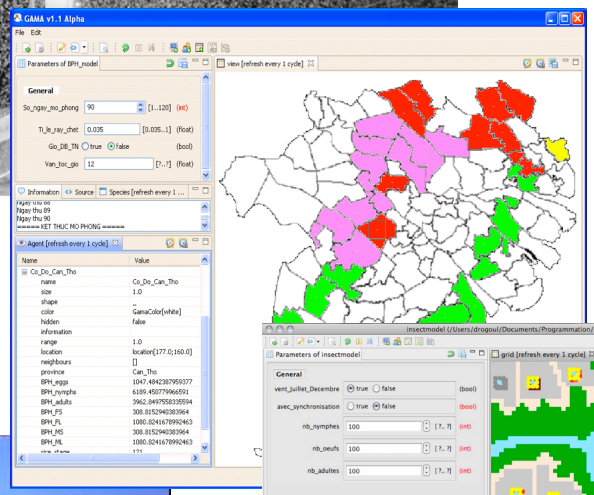


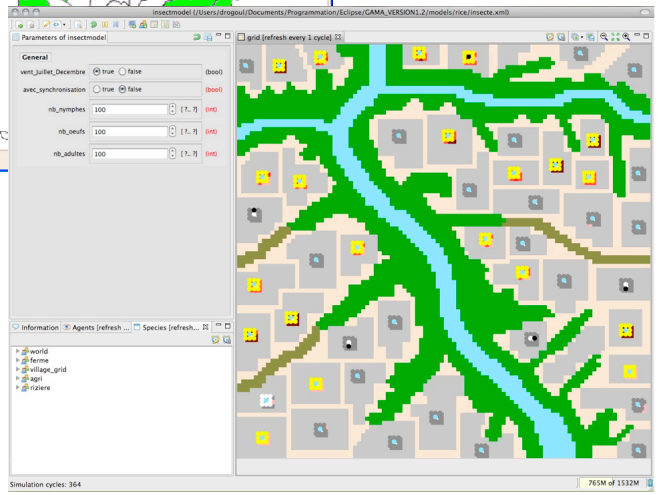




Agriculture, threads

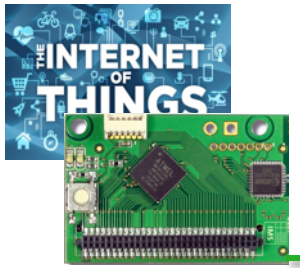




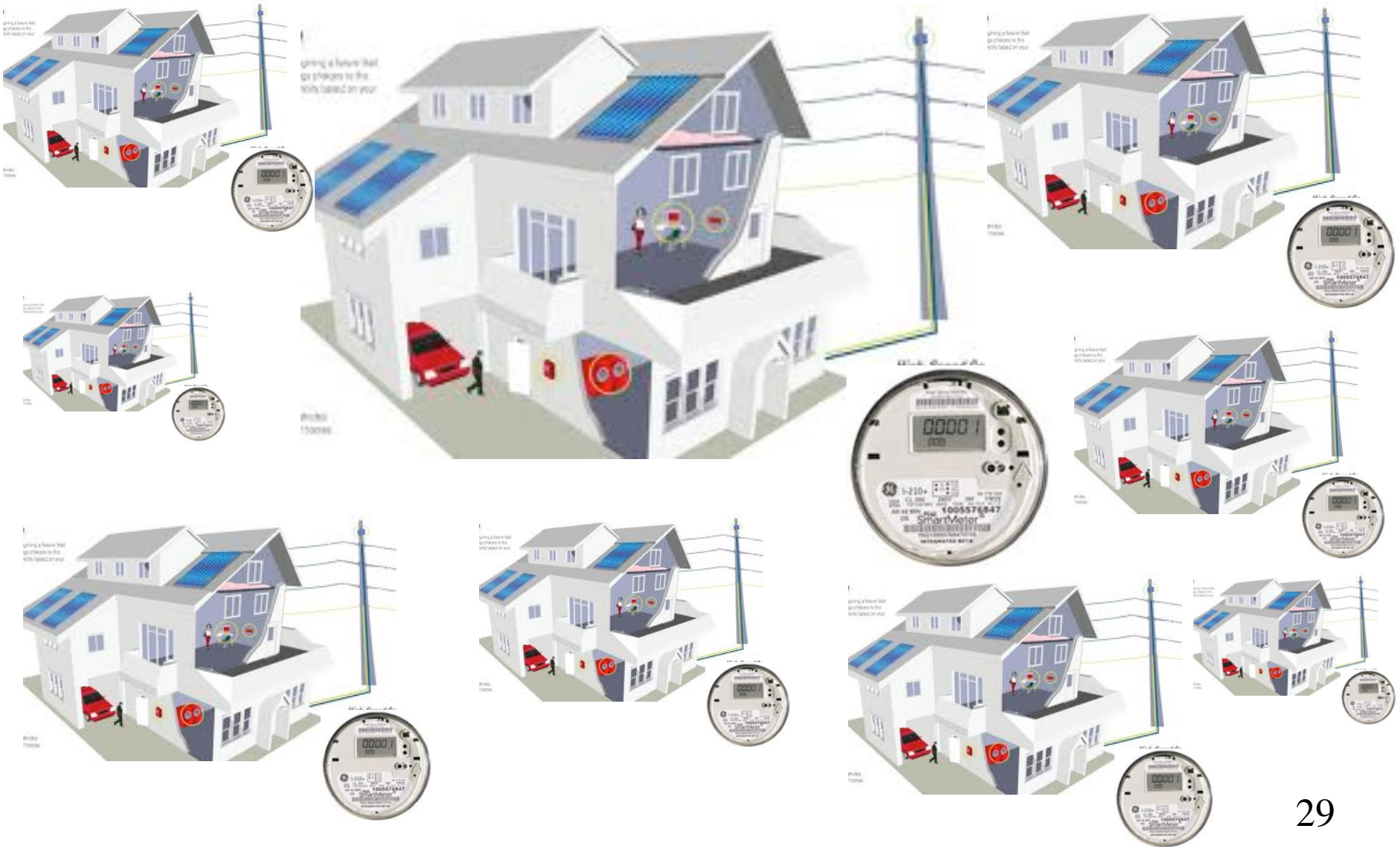


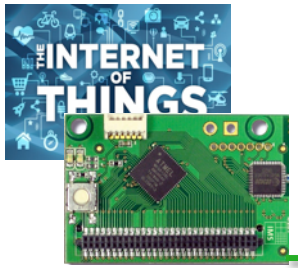
Source JEAI DREAM, U. Can Tho

Air quality, pollution

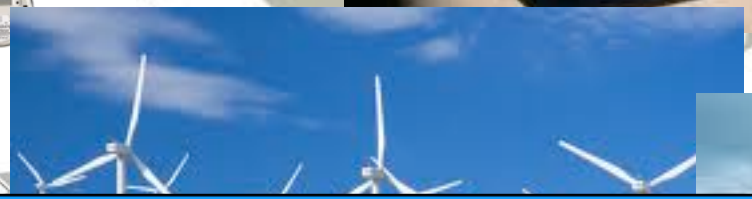


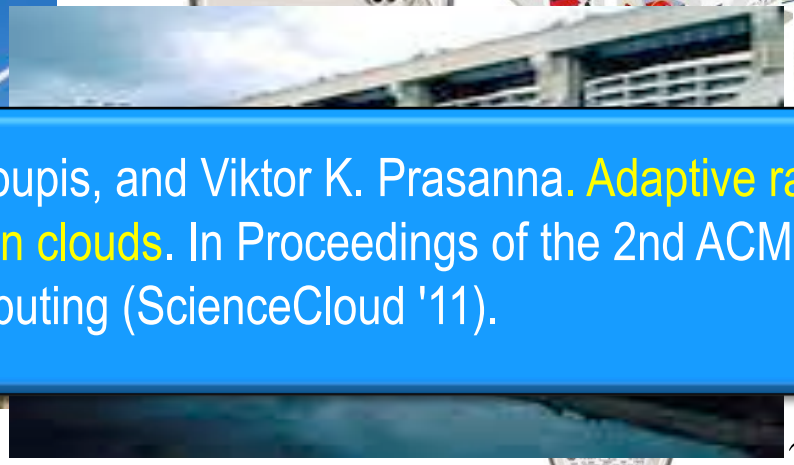
Energy & Electricity Grids



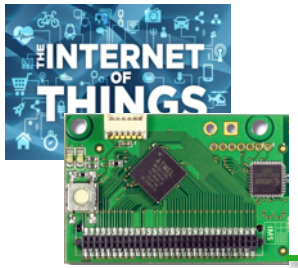


Energy & Electricity Grids

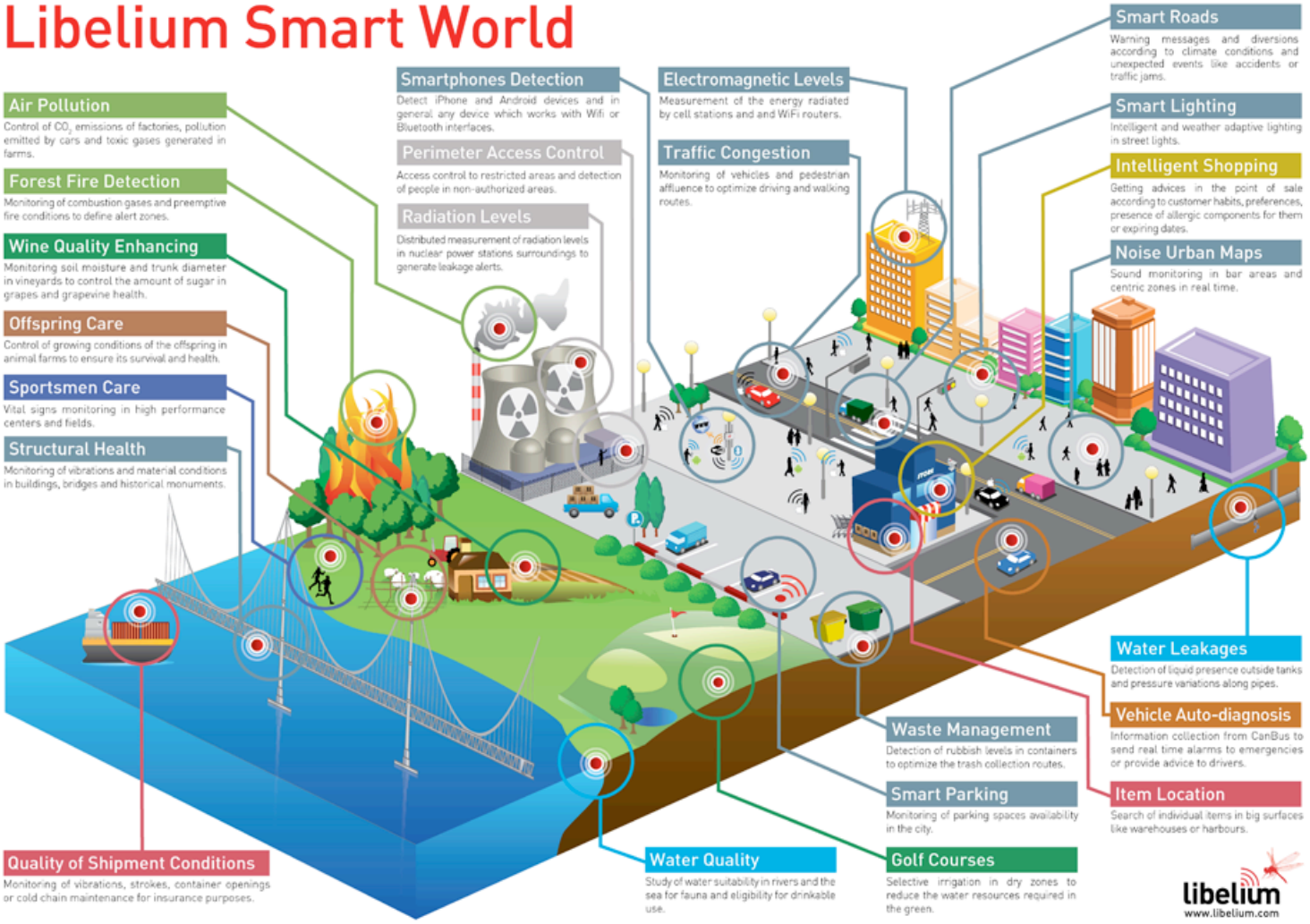




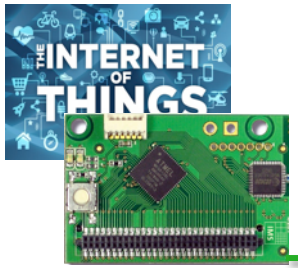
Yogesh Simmhan, Baohua Cao, Michail Giakkoupis, and Viktor K. Prasanna. Adaptive rate stream processing for smart grid applications on clouds. In Proceedings of the 2nd ACM international workshop on Scientific cloud computing (ScienceCloud '11).



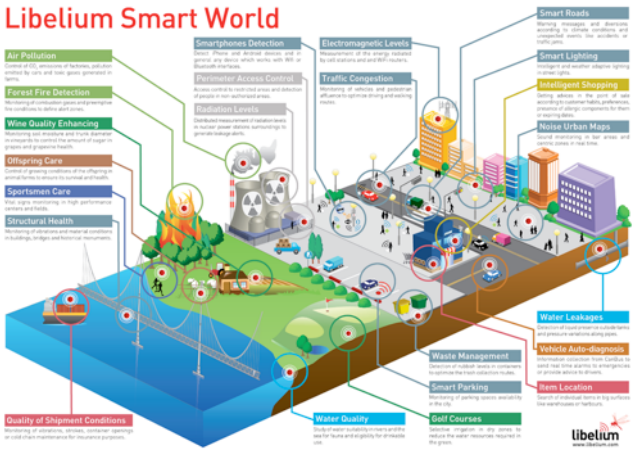
Smart Cities



HTTP://WWW.LIBELIUM.COM/TOP_50_IOT_SENSOR_APPLICATIONS_RANKING/#SHOW_INFOGRAPHIC

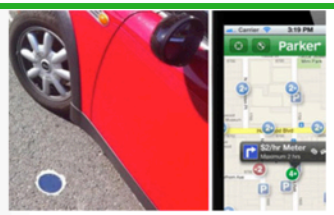


A BUSINESS MODEL IN SMARTCITIES



KEEP STREETS CLEAN

Products like the cellular communication enabled Smart Belly trash use real-time data collection and alerts to let municipal services know when a bin needs to be emptied. This information can drastically reduce the number of pick-ups required, and translates into fuel and financial savings for communities service departments. // Visit



STOP DRIVING IN CIRCLES

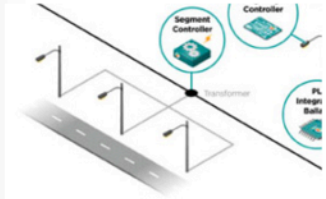
With the use of installed sensors, mobile apps, and real-time web applications like those provided in Streetline's ParkSight service, cities can optimize revenue, parking space availability and enable citizens to reduce their environmental impact by helping them quickly find an open spot for their cars. // Visit

RECEIVE POLLUTION WARNINGS

The DontFlushMe project by Leif Percifield is an example that combines sensors installed in Combined Sewer Overflows (CSOs) with alerts to local residents so they can avoid polluting local waterways with raw sewage by not flushing their toilets during overflow events. // Visit

USE ELECTRICITY MORE EFFICIENTLY

The SenseNET system uses battery-powered clamp sensors to quickly measure current on a line, calculate consumption levels, and send that data to a hosted application for analysis. Significant financial and energy resources are saved as the clamps can easily identify meter tampering issues, general malfunctions, and any installation issues in the system. // Visit



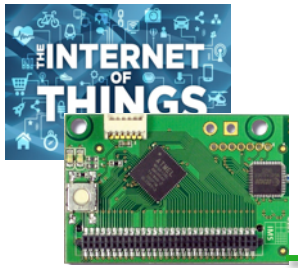
LIGHT STREETS MORE EFFECTIVELY

This smart lighting system from Echelon allows a city to intelligently provide the right level of lighting needed by time of day, season, and weather conditions. Cities have shown a reduction in street lighting energy use by up to 30% using solutions like this. // Visit

SHARE YOUR FINDINGS

AirCasting is a platform for recording, mapping, and sharing health and environmental data using your smartphone. Each AirCasting session lets you capture real-world measurements (Sound levels recorded by their phone microphone; Temperature, humidity, carbon monoxide (CO) and nitrogen dioxide (NO2) gas concentrations), and share it via the CrowdMap with your community. // Visit

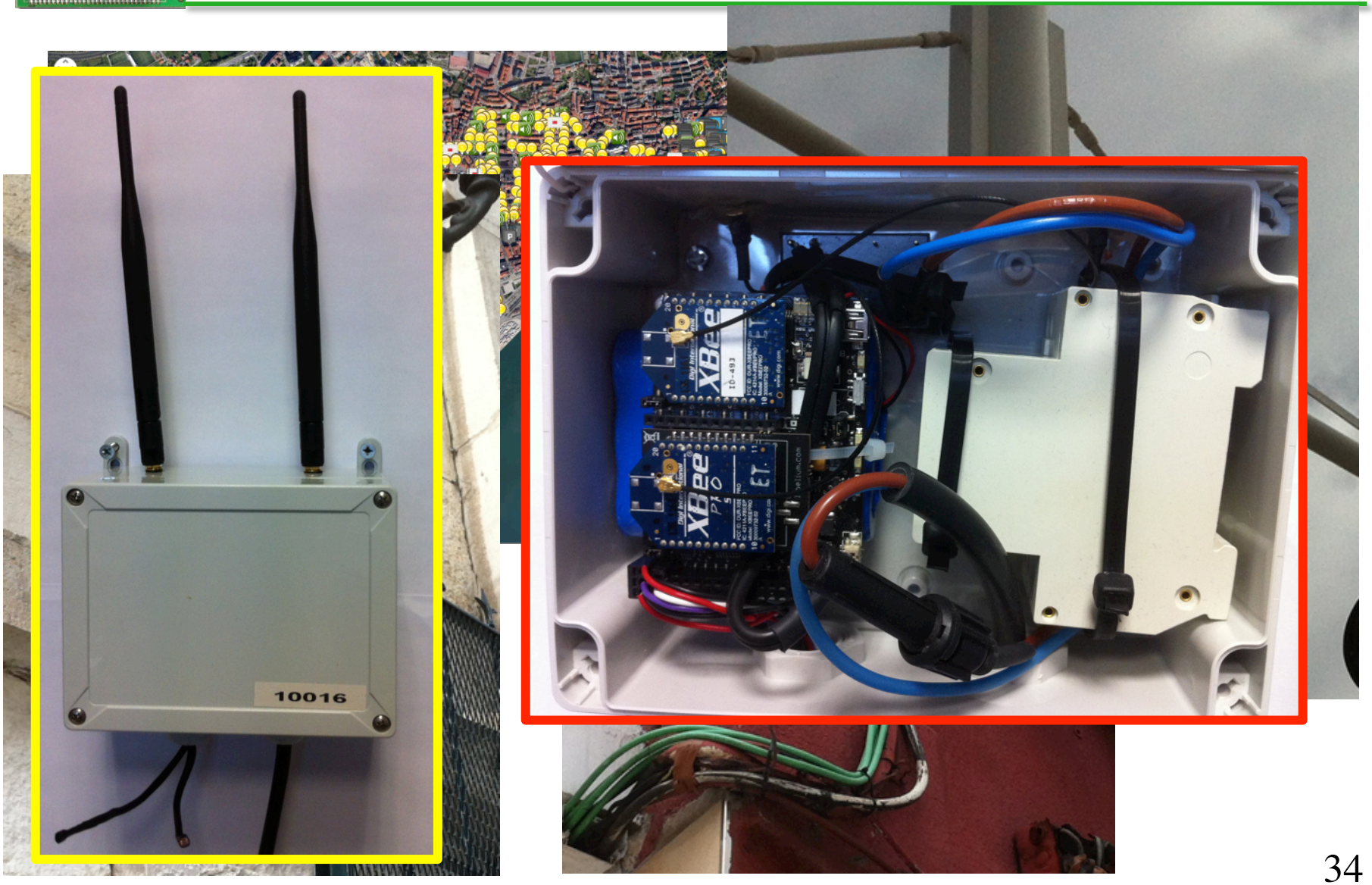
http://www.postscapes.com/internet-of-things-examples/

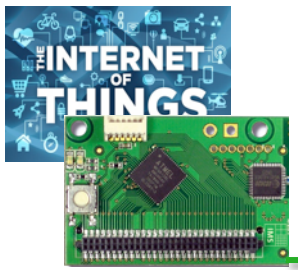


SmartSantander

www.smartsantander.eu

SmartSantander nodes





Who is concerned?

GLOBAL SENSING SCENARIO

Activating

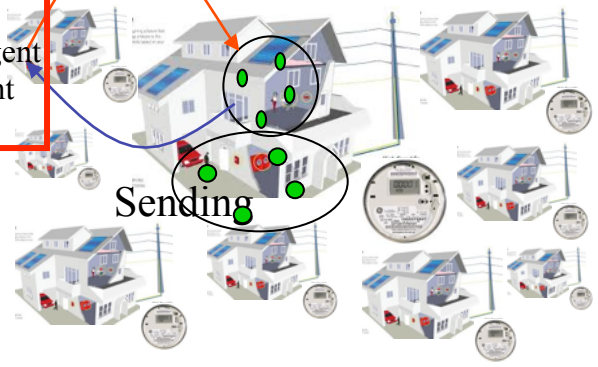
Intelligent Agent

Sending

Activating

Intelligent Agent

Sending



Activating

Intelligent Agent

Sensor Net

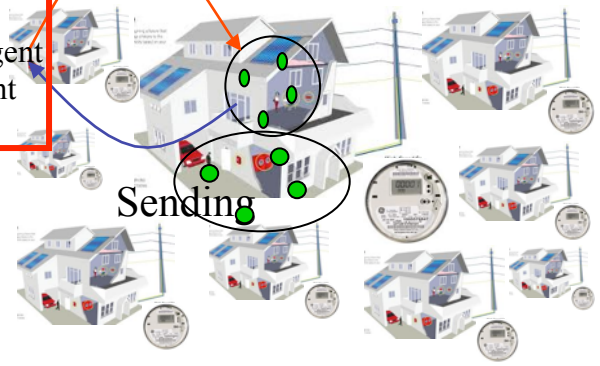
Sending

The Rise of Big Data

Activating

Intelligent Agent

Activating



Intelligent Agent

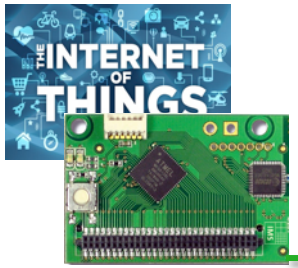
Sending

Activating

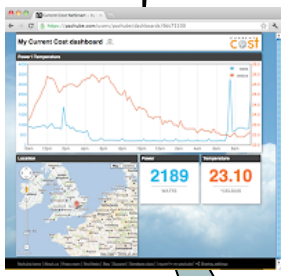
Intelligent Agent

Sensor Net

Sending



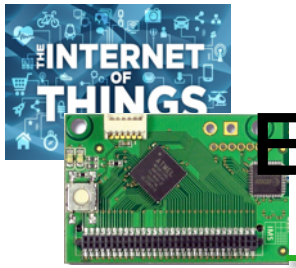
Control, optimize & Instrument



Pervasive Systems

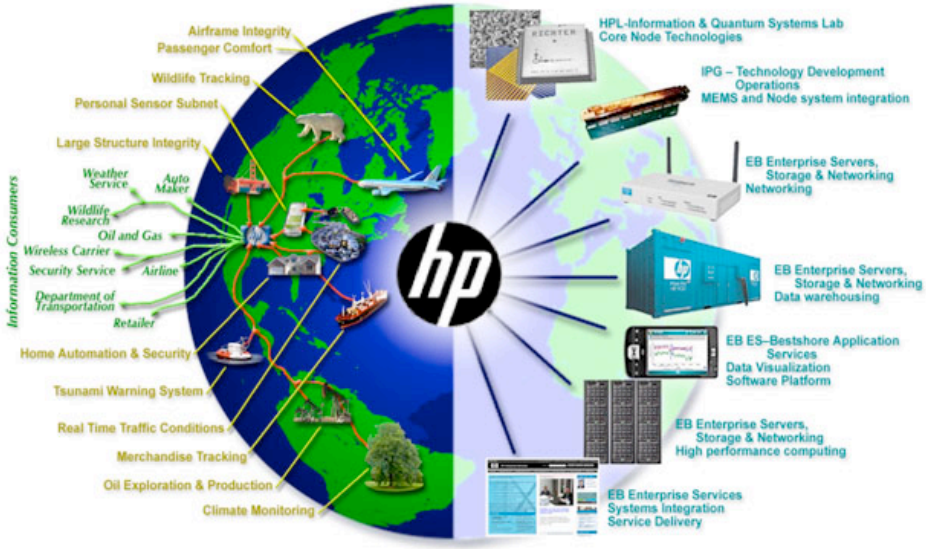
Sensing

PEOPLES, INFRASTRUCTURES, BUILDINGS, VEHICULES

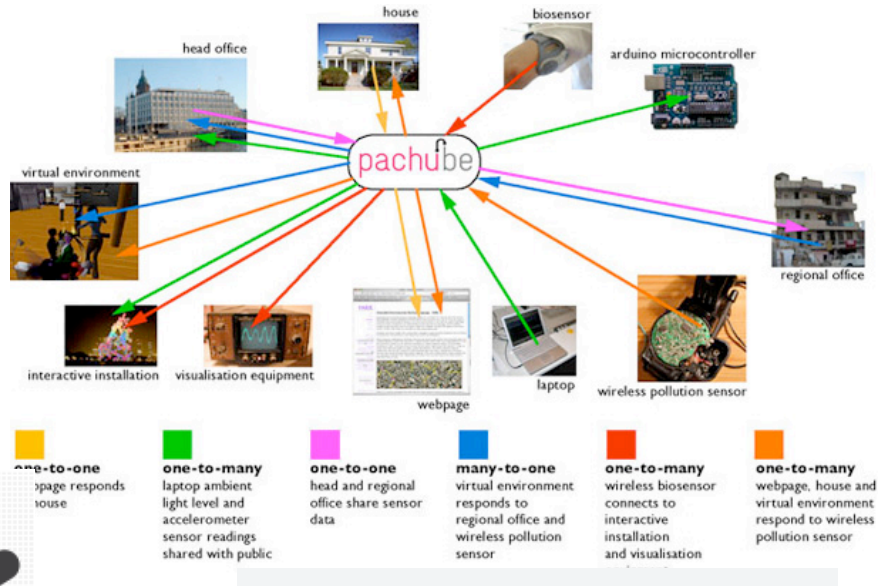


Big actors for big data

HP CeNSE



Pachube/Cosm



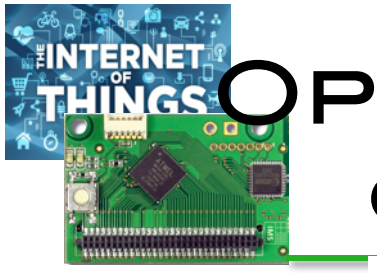
IBM Smarter Planet

IBM

cosm™ BETA

Connect to your world

http://readwrite.com/2010/12/15/top_10_internet_of_things_developments_of_2010



Opportunities for Telco operators & more...

Transmission rate

Roving Networks, a leading provider of wireless solutions announced the RN-XVee, its new ultra-low power, through hole 802.11 b/g module that is drop in compatible with existing 802.15.4 modules. 2011

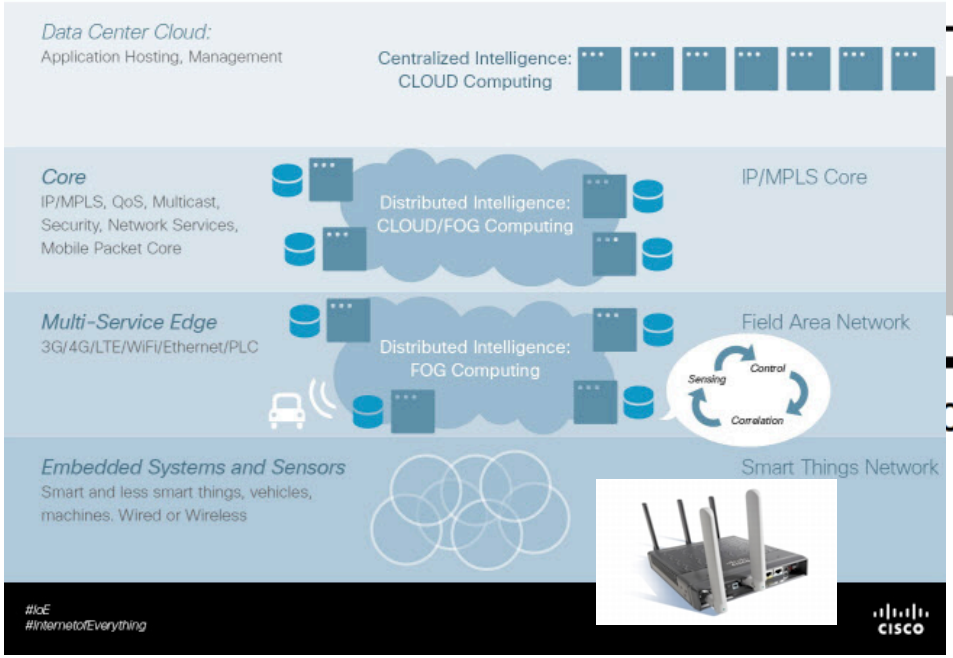
UMTS, HDPA, LTE, LTE-A

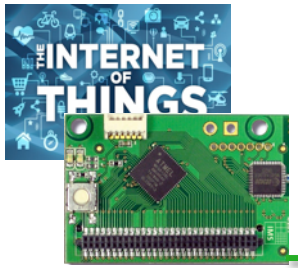
Opportunity for M2M

00 m 1 Km 10 Km

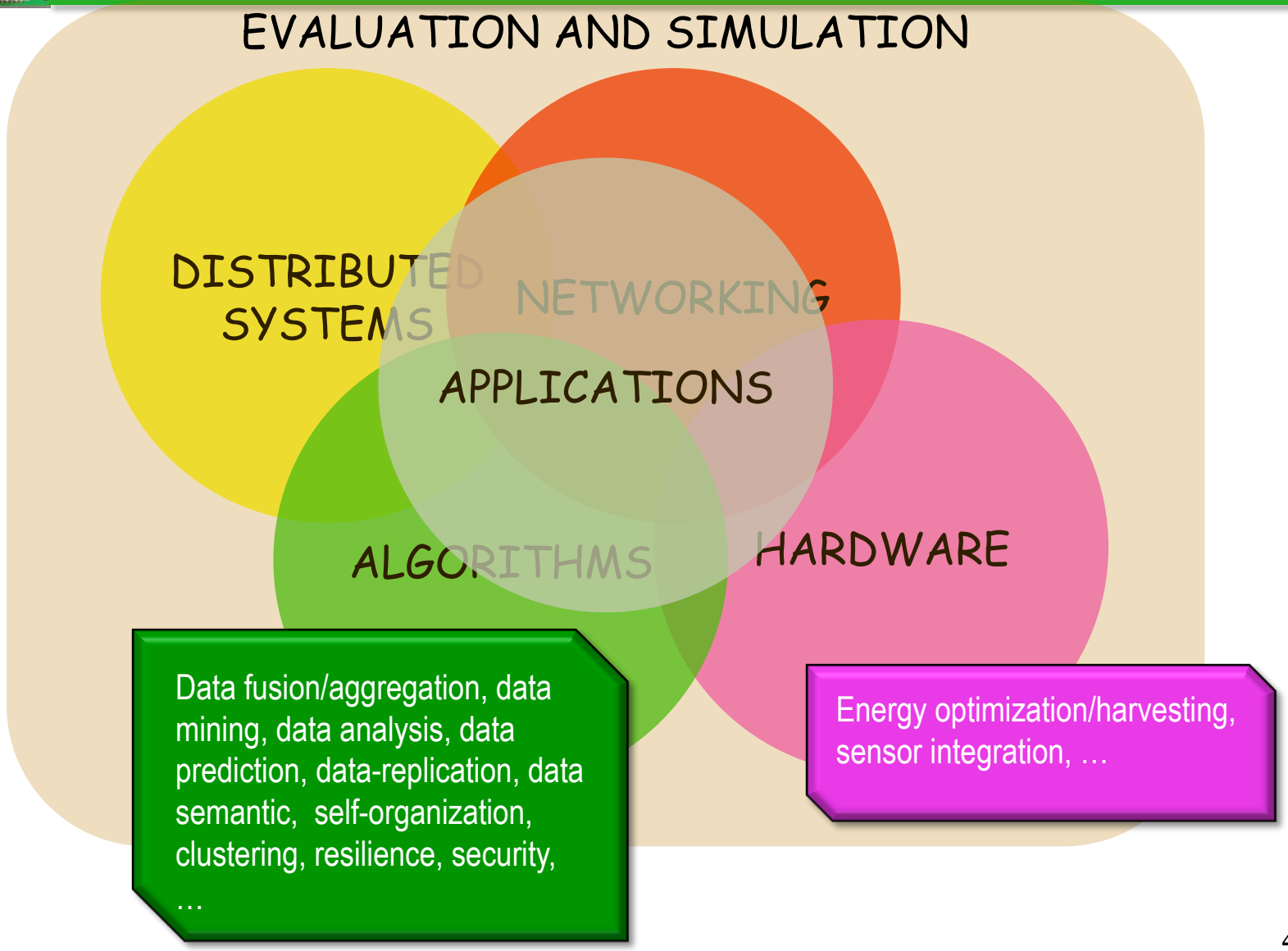
in SmartCities"

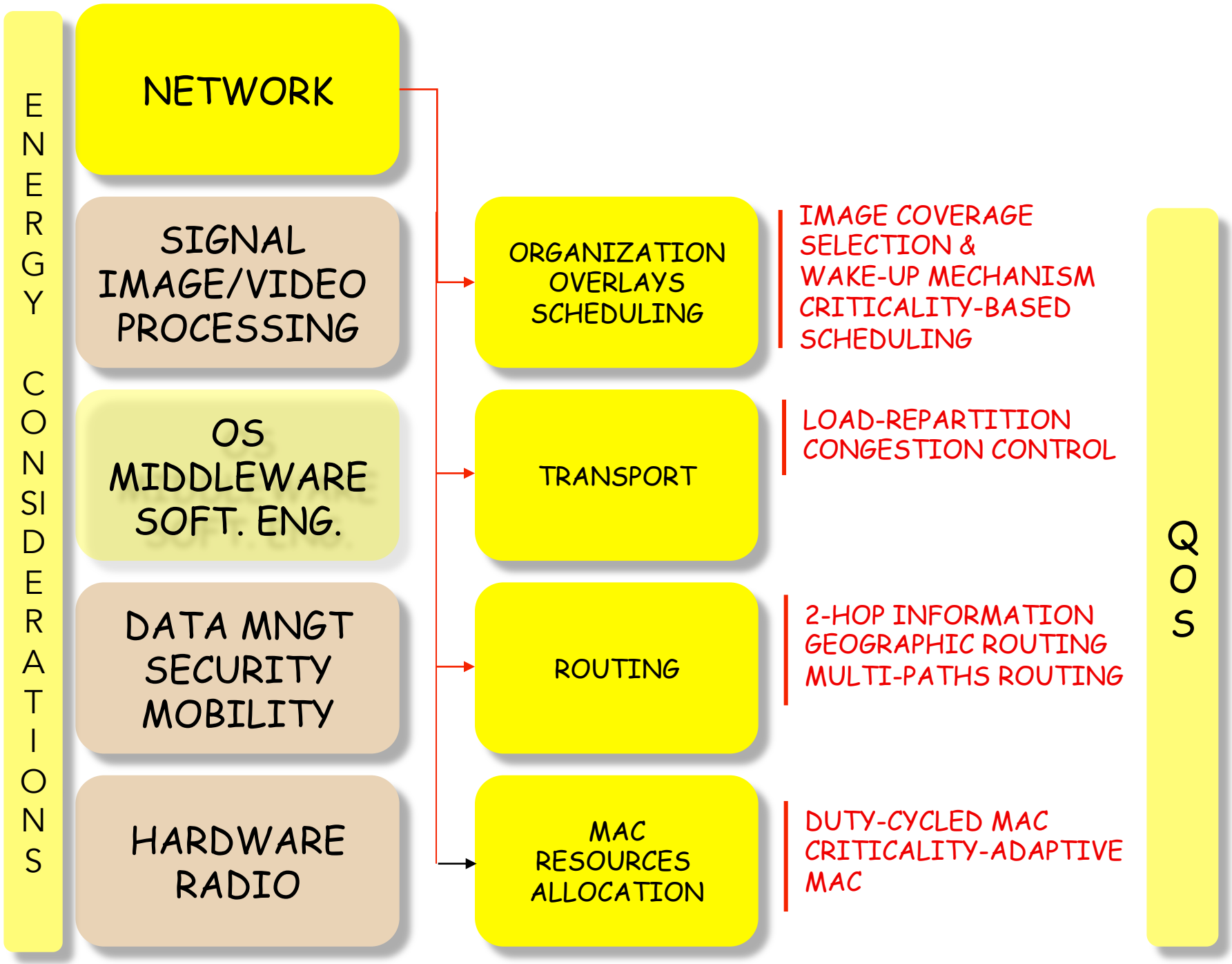
The "Common" Cisco IoT Platform Architecture General Functionality

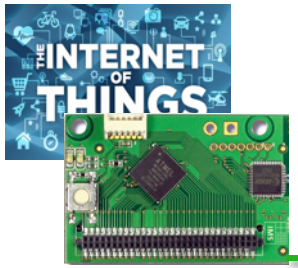




Multi-disciplinary research



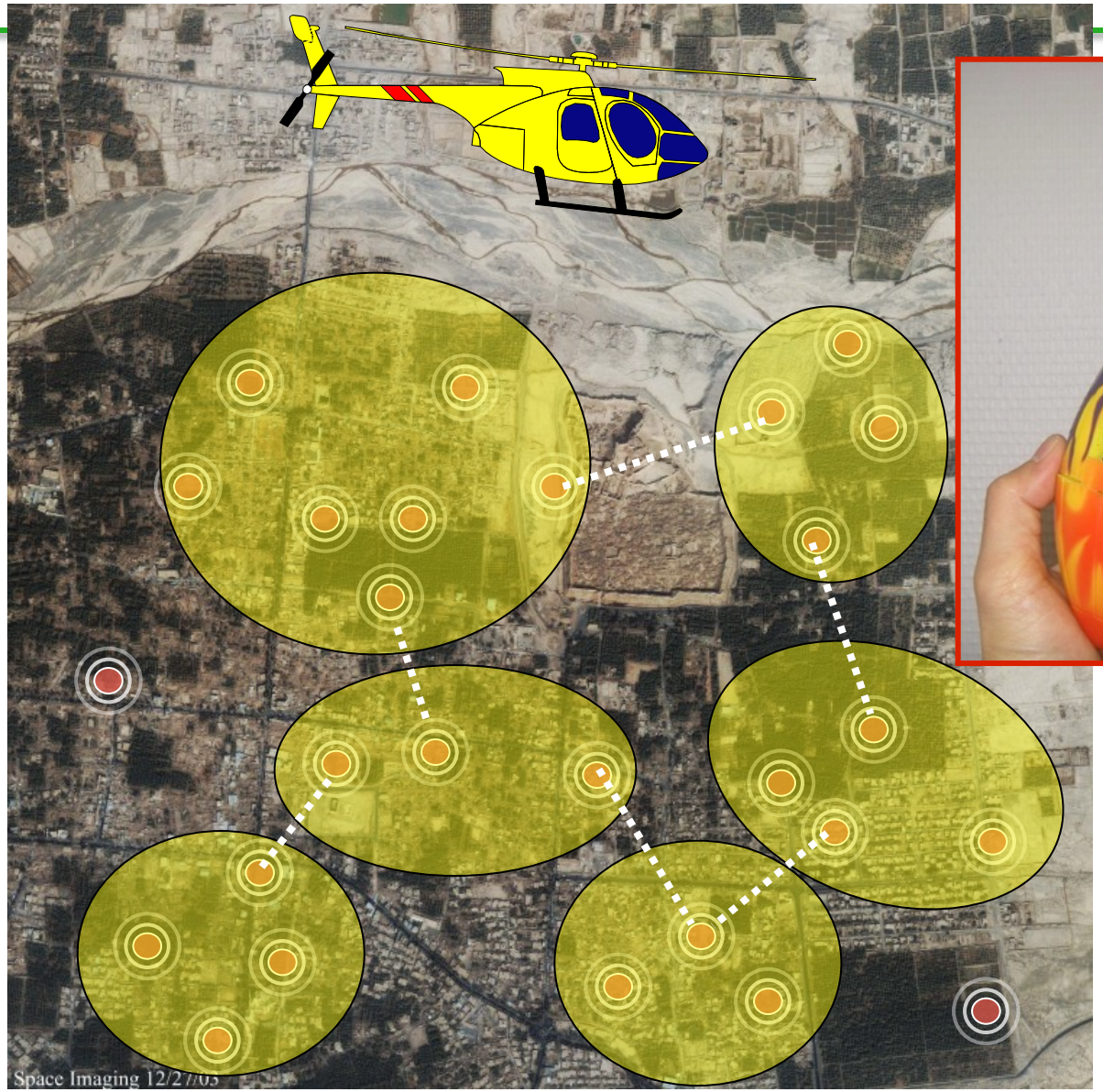

ENERGY CONSIDERATIONS
NETWORK
SIGNAL IMAGE/VIDEO PROCESSING
OS MIDDLEWARE SOFT. ENG.
DATA MNGT SECURITY MOBILITY
HARDWARE RADIO
ORGANIZATION OVERLAYS SCHEDULING
TRANSPORT
ROUTING
MAC RESOURCES ALLOCATION
IMAGE COVERAGE SELECTION & WAKE-UP MECHANISM CRITICALITY-BASED SCHEDULING
LOAD-REPARTITION CONGESTION CONTROL
2-HOP INFORMATION GEOGRAPHIC ROUTING MULTI-PATHS ROUTING
DUTY-CYCLED MAC CRITICALITY-ADAPTIVE MAC
QOS

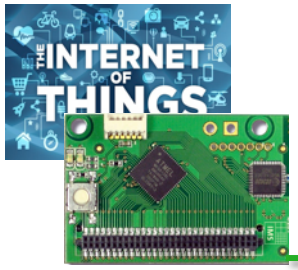


Some contributions « from theory to practice »

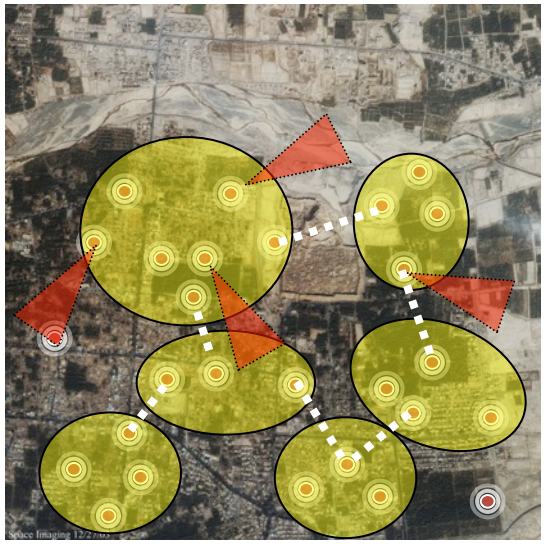
Image and acoustic for surveillance

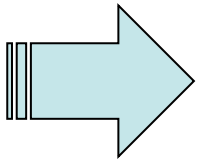
Search&Rescue, security



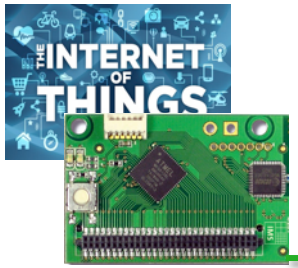


Situation-awareness





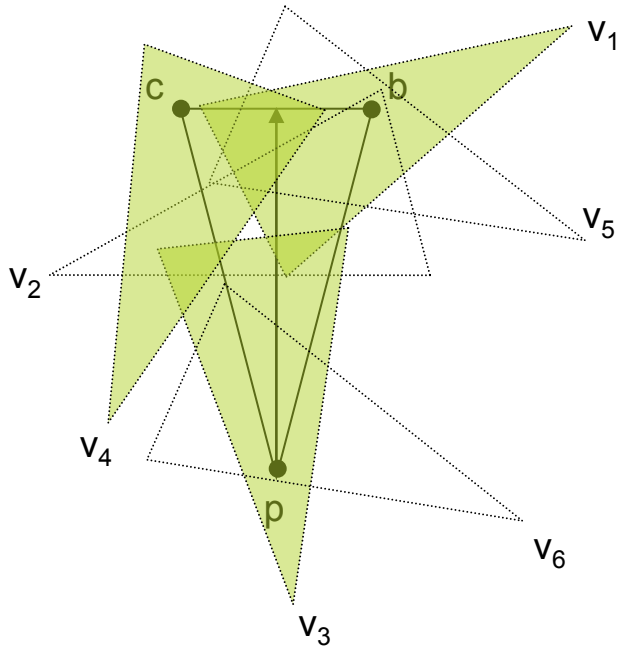
Collect data to improve the responsiveness of rescue operations

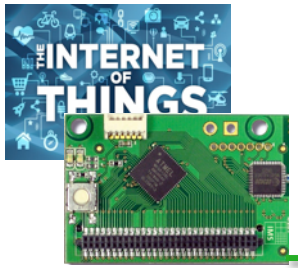


Node's cover set

Co(V)= {
{V },
{V_1, V_3, V_4},
{V_2, V_3, V_4},
{V_3, V_4, V_5},
{V_1, V_4, V_6},
{V_2, V_4, V_6},
{V_4, V_5, V_6}
}

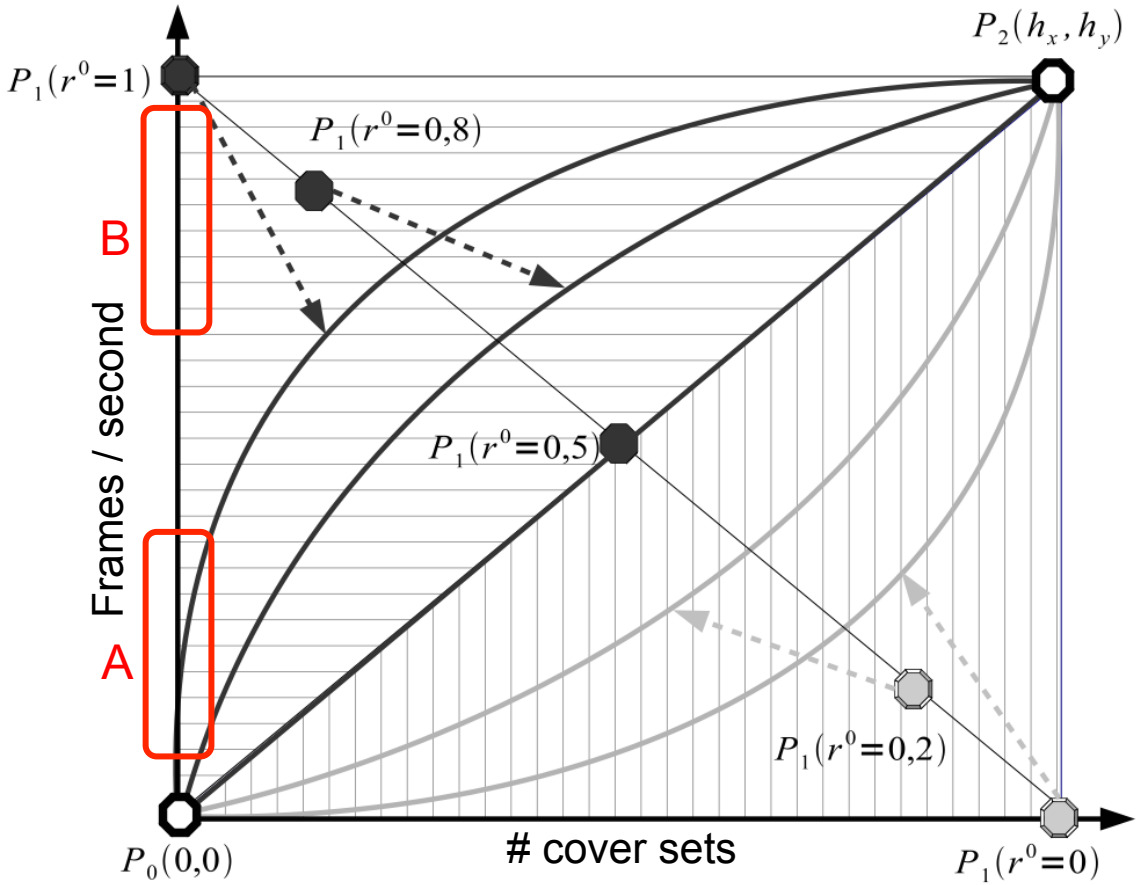
|Co(V)| = 7



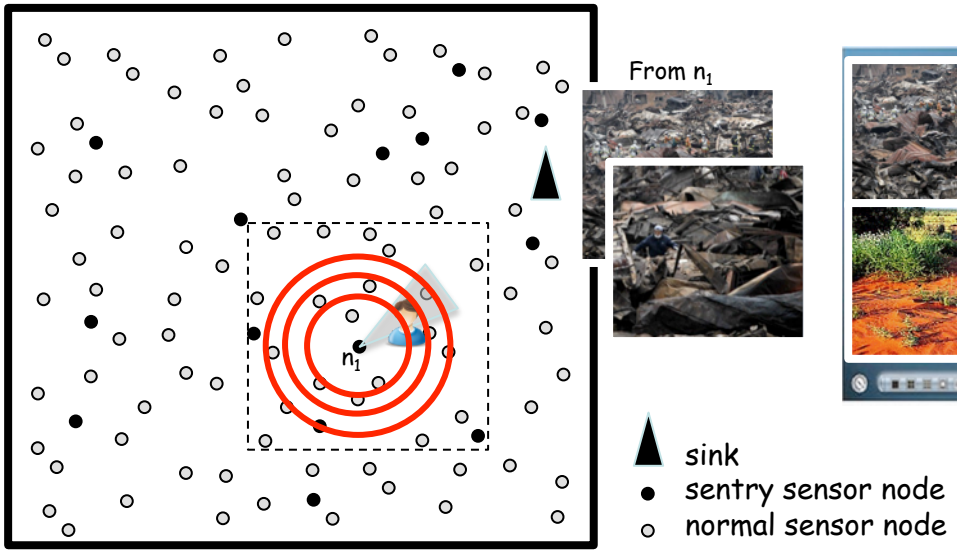


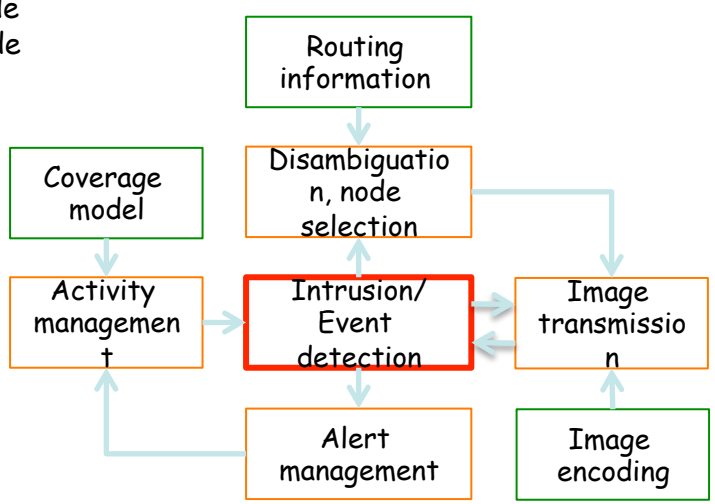
Criticality model

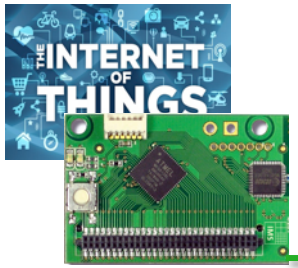
- r^0 can vary in [0,1]
- Behavior functions (BV) defines the capture speed according to r^0
- $r^0 < 0.5$
  - Concave shape BV
- $r^0 > 0.5$
  - Convex shape BV
- We propose to use Bezier curves to model BV functions



Criticality-based scheduling



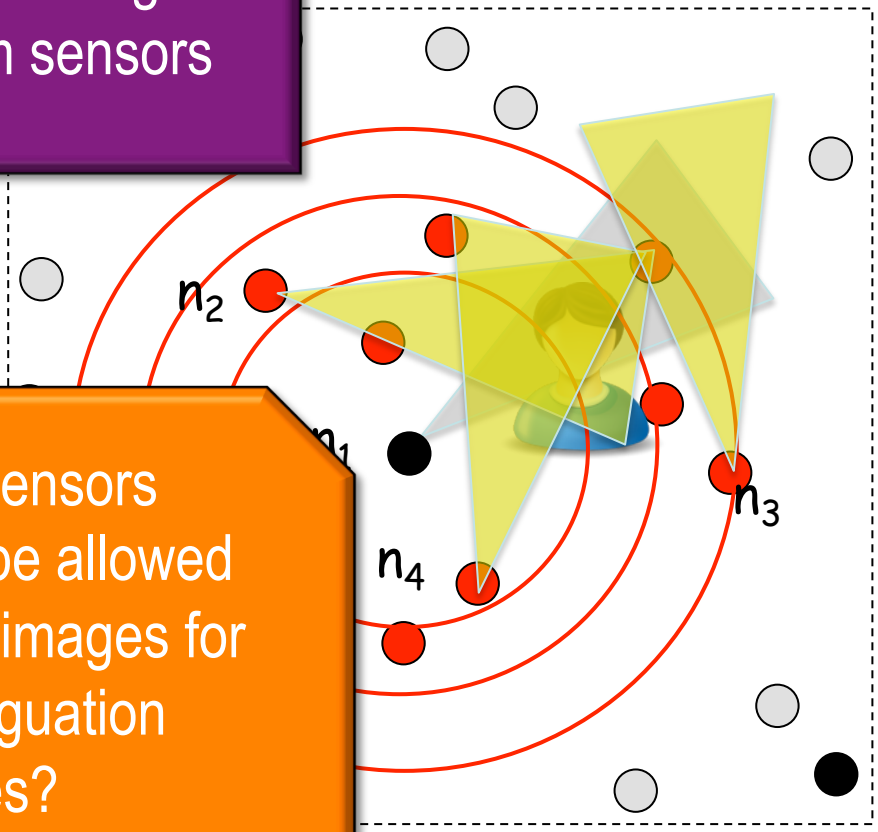


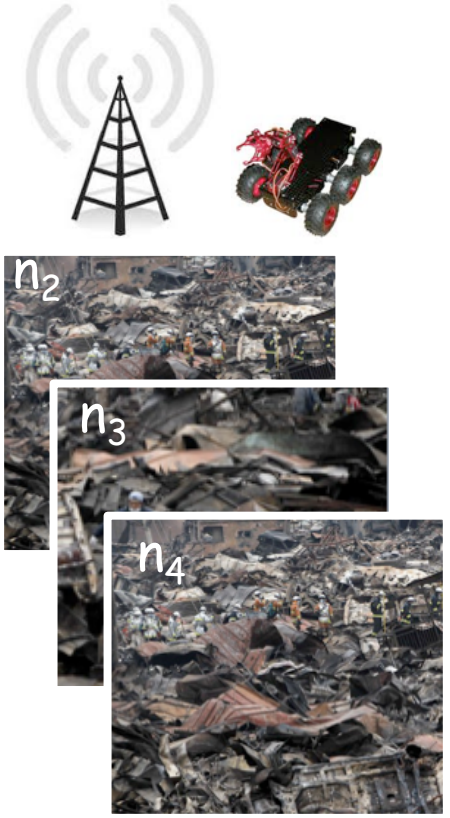


On event detection

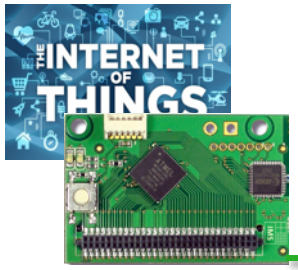
Must limit the number of images sent from sensors

Which sensors should be allowed to send images for disambiguation purposes?



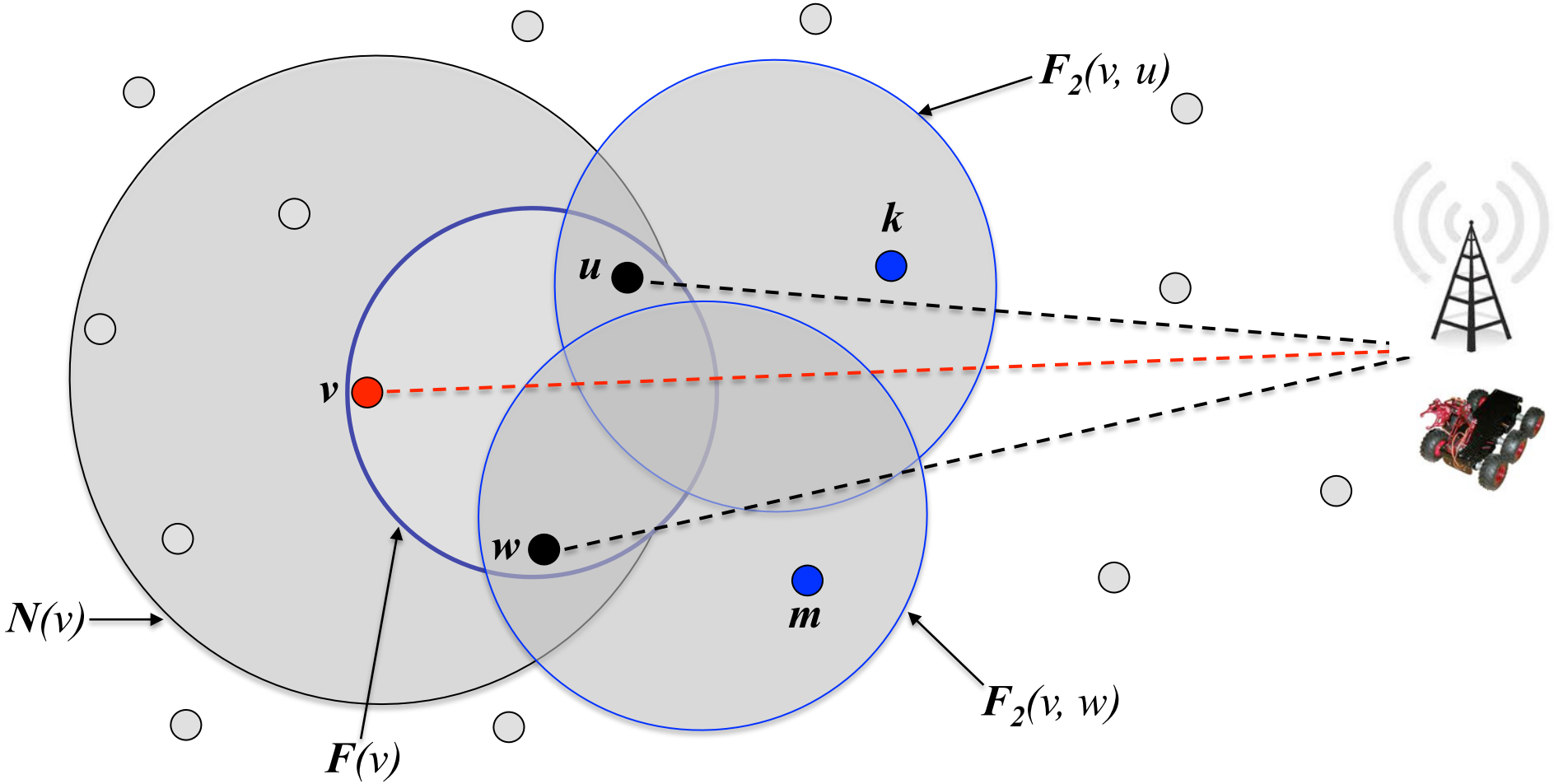


alerted node

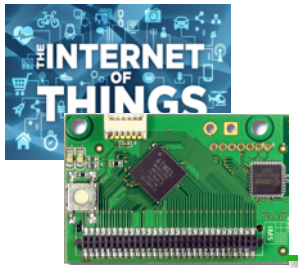


2-HOP INFORMATION

$$\mathbf{F_2}(v,u) = \left\{ k | d(k, Sink) < d(u, Sink), u \in F(v), k \in N(u) \right\}$$



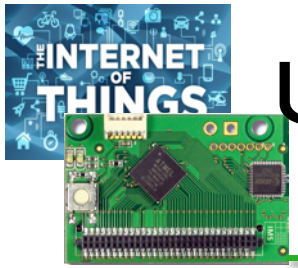
$$\mathbf{F}(v) = \left\{ u | d(u, Sink) < d(v, Sink), u \in N(v) \right\}$$



#IMAGES & #PATHS LIKELIHOOD

$$R_{2-hop}(Co_i(v)) = \frac{1}{|Co_i(v)|} \sum_{w=1}^{|Co_i(v)|} \frac{|F_2(w)|}{NbOptimalPaths(w)}$$

- $R_{2\text{-HOP}}$ MEASURES THE LIKELIHOOD OF A GIVEN COVER SET TO FIND AS MANY NEEDED 2-HOP PATHS AS REQUIRED BY THE CAPTURE RATE OR # OF IMAGES

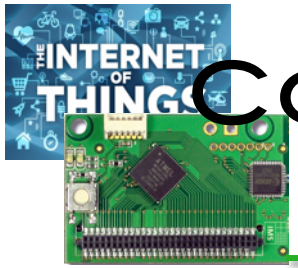


Unshared relay nodes likelihood

- 2-hop potential forwarders may have few relay nodes themselves
- A cover set with many unshared relay nodes per 2-hop forwarder has better efficiency

$$R_{relay}(Co_i(v)) = \frac{1}{|Co_i(v)|} \sum_{w=1}^{|Co_i(v)|} \frac{|F(w)|}{|F_2(w)|}$$

- The $\frac{|F(w)|}{|F_2(w)|}$ ratio expresses the likelihood that a 2-hop forwarder has several unshared relay nodes



Cover-set's transmission quality factor

- Each cover set is then associated to a Transmission Quality (TQ)
- TQ is used to score and classify cover sets at a sentry node

$$TQ(Co_i(v)) = \alpha \times R_{2-hop}(Co_i(v)) + \beta \times R_{relay}(Co_i(v))$$

- **α+β = 1.**

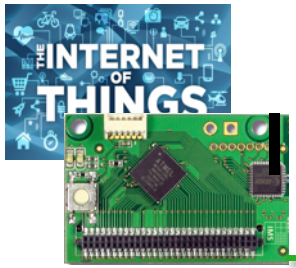
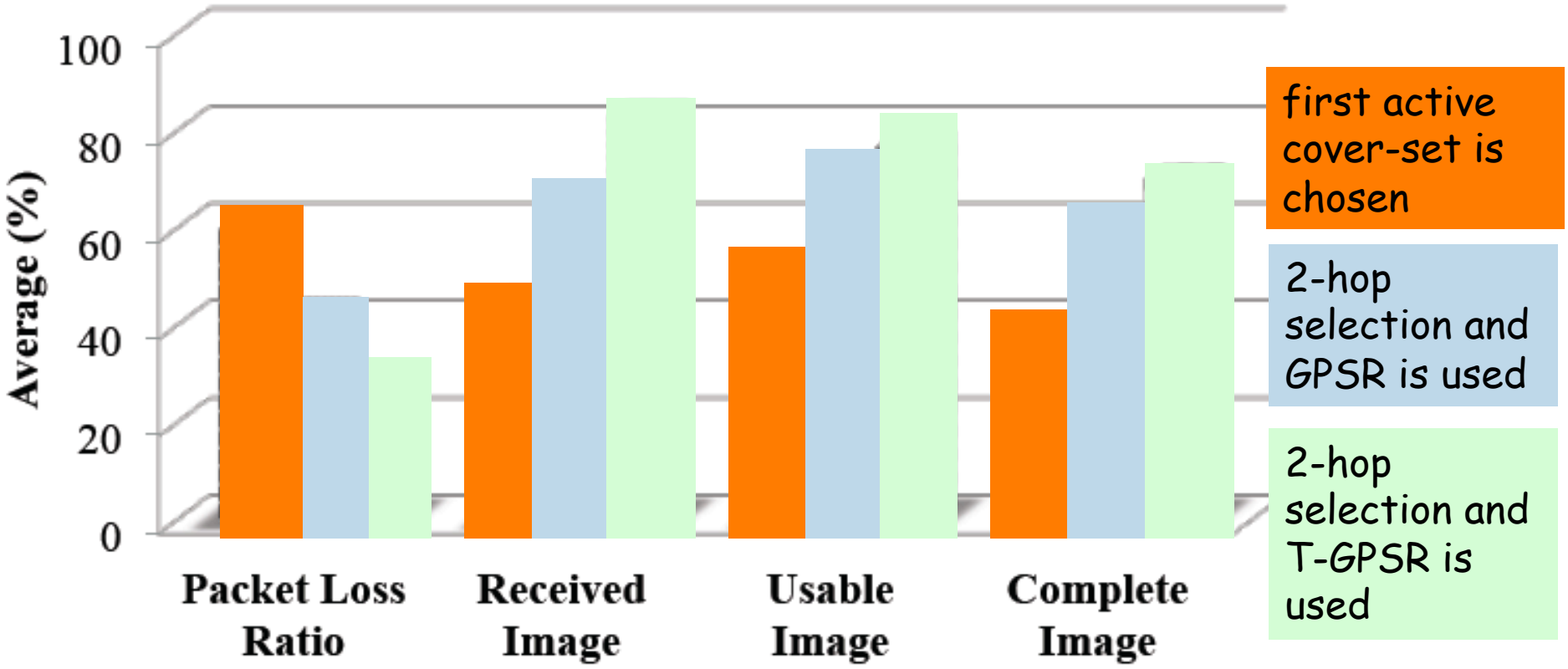
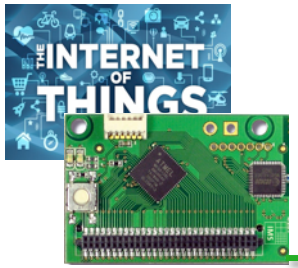


IMAGE STATISTICS AT SINK

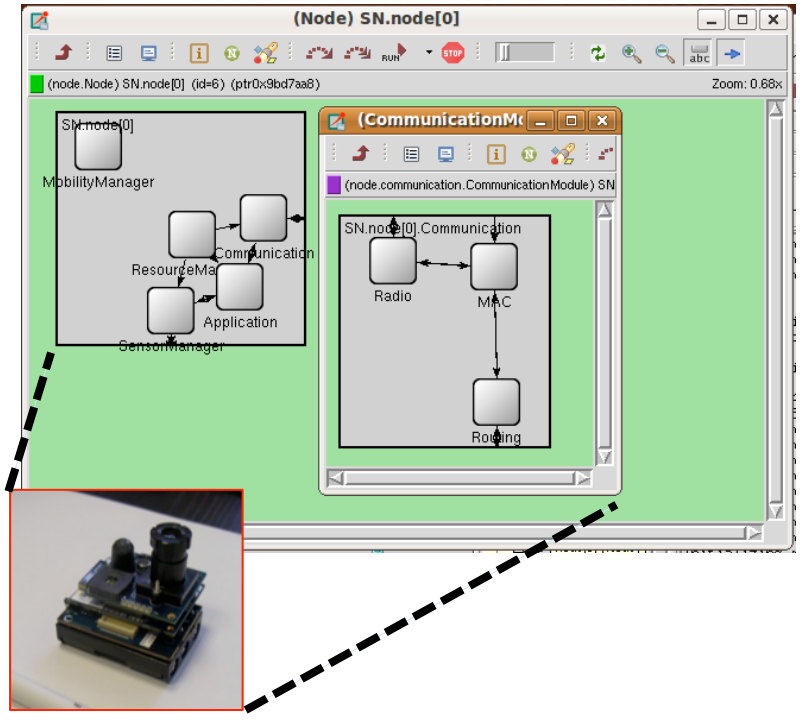


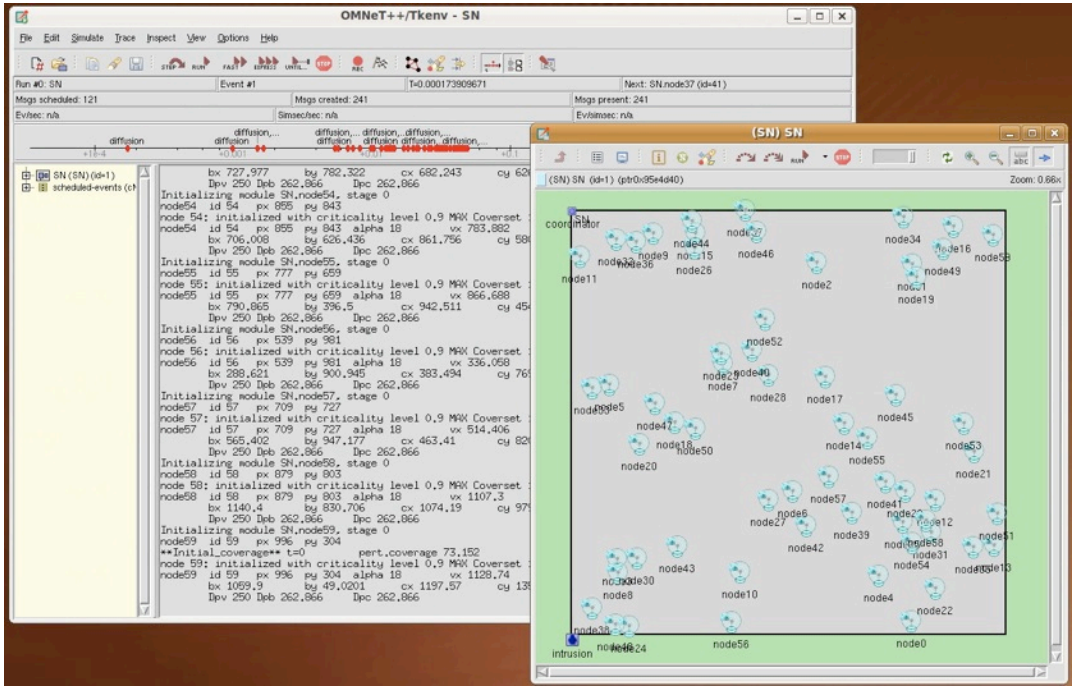
- AN IMAGE WITH MORE THAN 60% PKT LOSSES IS SAID UNUSABLE



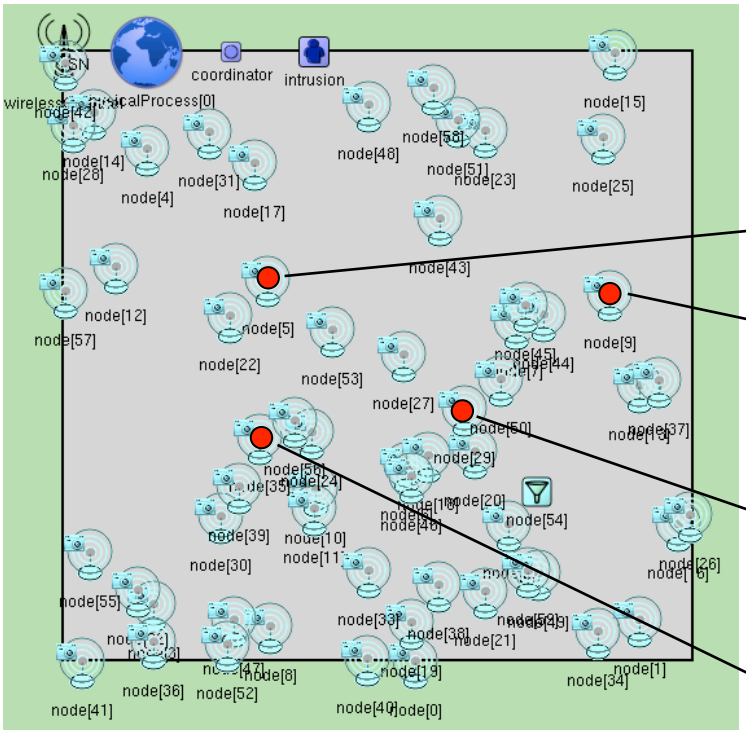
Multimedia sensor simulation model

- Advanced propagation and radio models
- Layered, flexible architecture





Some images displayed by the sink



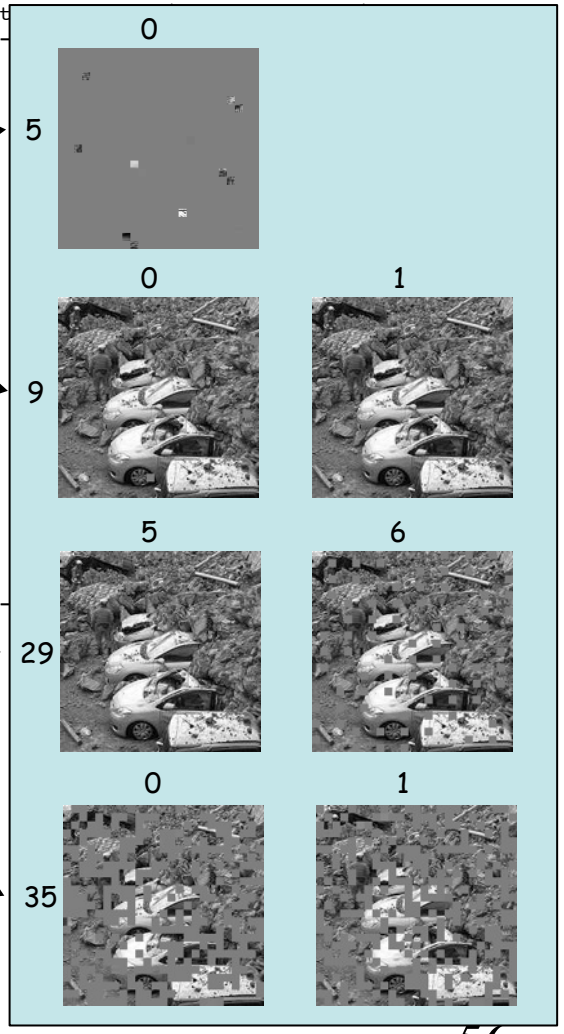
60 image sensor nodes
75mx75m
1 sink (node 54)

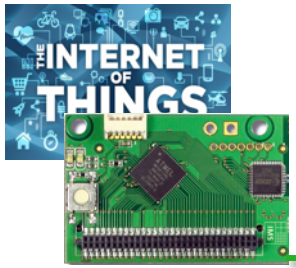
Application:Image sent

	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

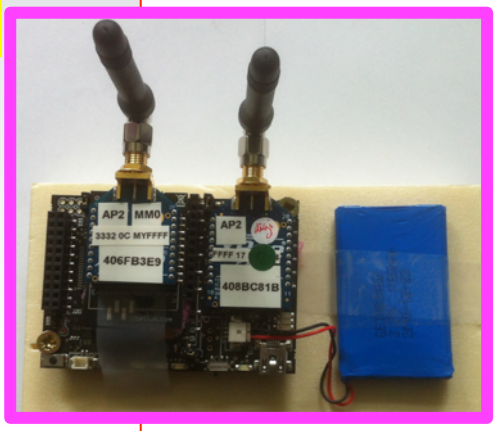




Mass-market sensors

8MHz Atmega1281
8kB SRAM, 128kB Flash
Xbee radio

Cost: ~100€

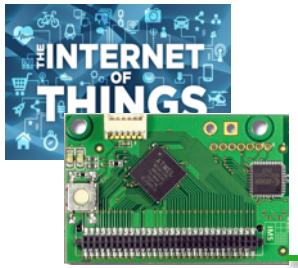


Libelium WaspMote

Cost: ~80€

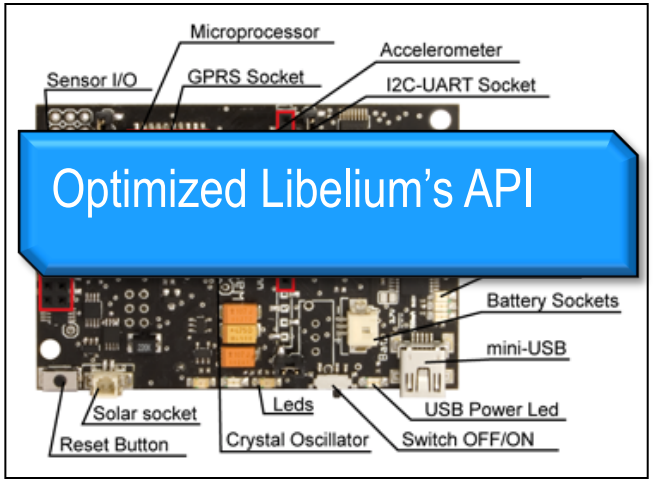
Arduino Mega2560

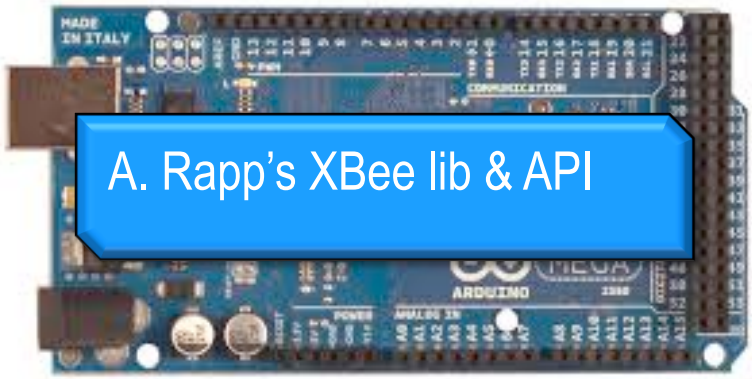
16MHz Atmega1281
8kB SRAM, 128kB Flash
Xbee radio



Sensor's HW&SW

Libelium WaspMote



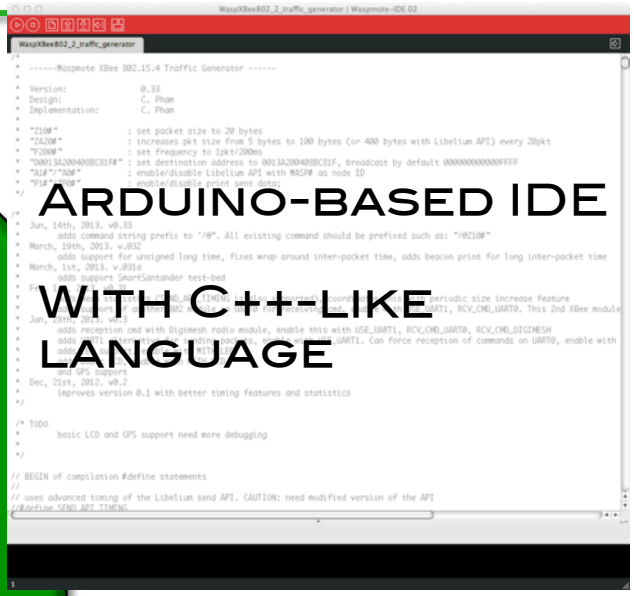


Arduino Mega2560

UART-based connection to micro-controller

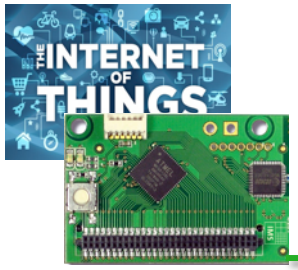
Default speed is usually 38400 bauds

Higher baud rate are possible but…

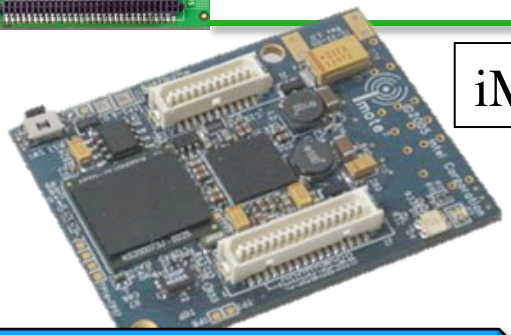


Arduino-based IDE with C++-like language

XBee 802.15.4

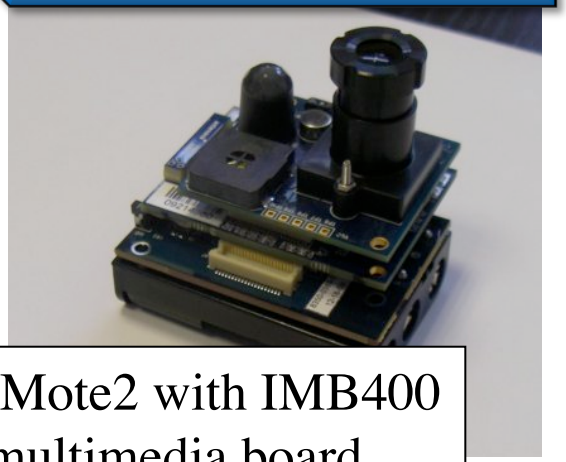


« Academic » sensors



iMote2

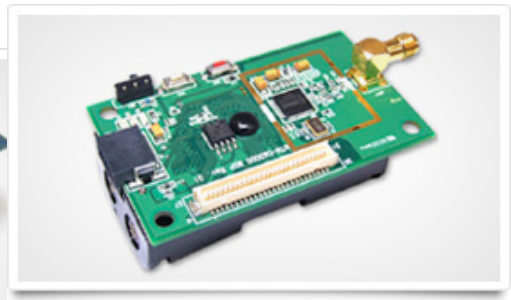
13-416MHz PXA271 Xscale
Wireless MMX DSP
256kB SRAM, 32MB Flash,
32MB SDRAM
CC2420 radio



iMote2 with IMB400
multimedia board

MICAz

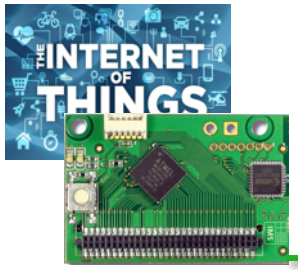
8MHz Atmega128L
4kB SRAM, 128kB Flash
CC2420 radio



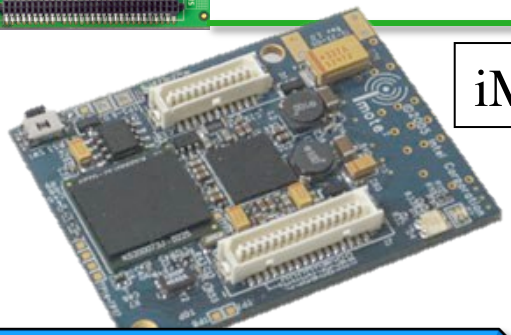
AdvanticSys CM5000 & CM3000
TelosB-like mote

TelosB

8Mhz MSP430F1611
10K SRAM, 48K flash
CC2420 radio

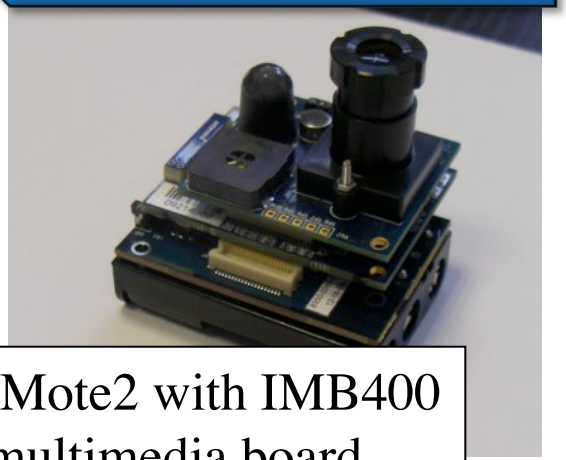


« Academic » sensors



iMote2

13-416MHz PXA271 Xscale
Wireless MMX DSP
256kB SRAM, 32MB Flash,
32MB SDRAM
CC2420 radio



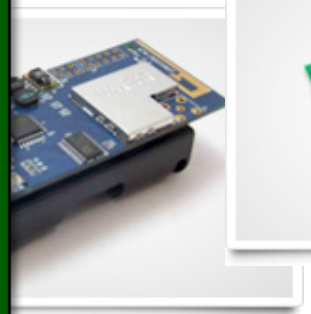
iMote2 with IMB400
multimedia board

Radio module
CC2420 is
connected
through SPI bus

SPI speed is in
the order of
several
hundredth kbps

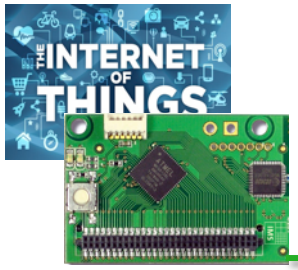
TelosB

8MHz Atmega128L
4kB SRAM, 128kB Flash
CC2420 radio

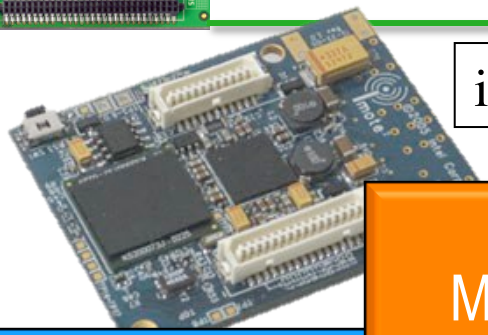


AdvanticSys CM5000 & CM3000
TelosB-like mote

8Mhz MSP430F1611
10K SRAM, 48K flash
CC2420 radio



« ACADEMIC » SENSORS



iMote2

8MHz Atmega128L
4kB SRAM, 128kB Flash
CC2420 radio

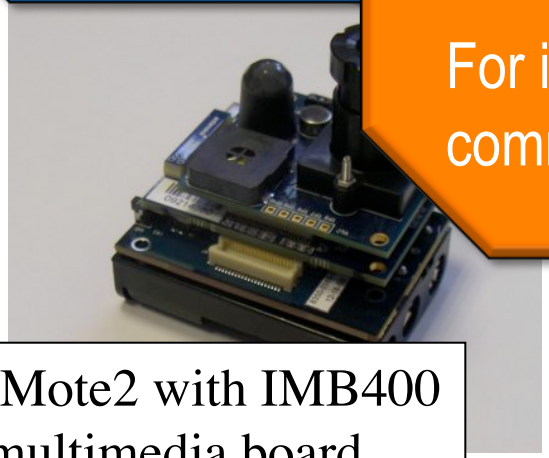
13-416MHz PXA271
Wireless MMX DSP
256kB SRAM, 32MB
32MB SDRAM
CC2420 radio

Motes are programmed under the TinyOS operating system & lib

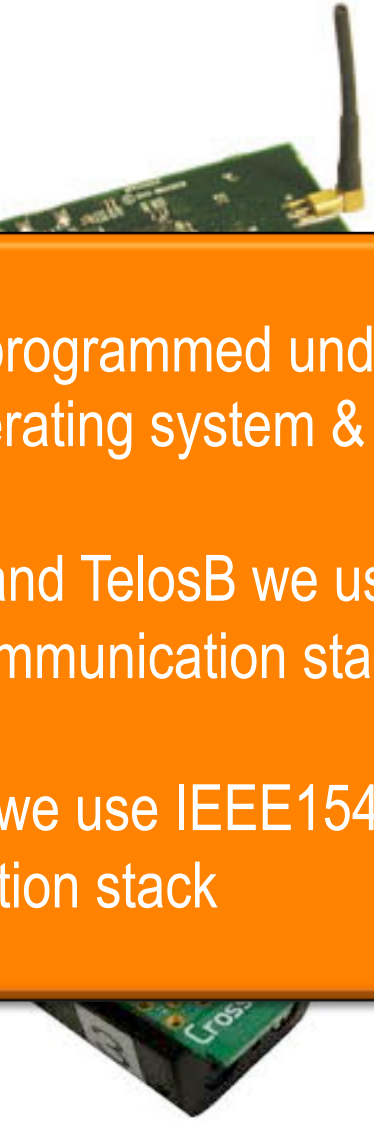
For MicaZ and TelosB we use TKN154 communication stack

For iMote2 we use IEEE154 communication stack

s CM5000 & CM3000
mote



iMote2 with IMB400
multimedia board

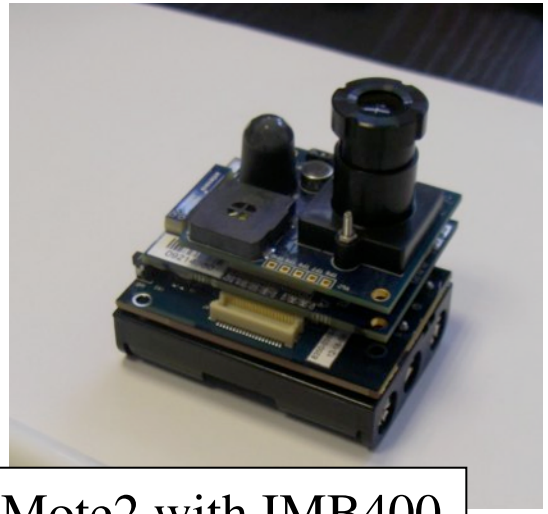


TelosB

8Mhz MSP430F1611
10K SRAM, 48K flash
CC2420 radio

Previous Image sensor motes

iMote2

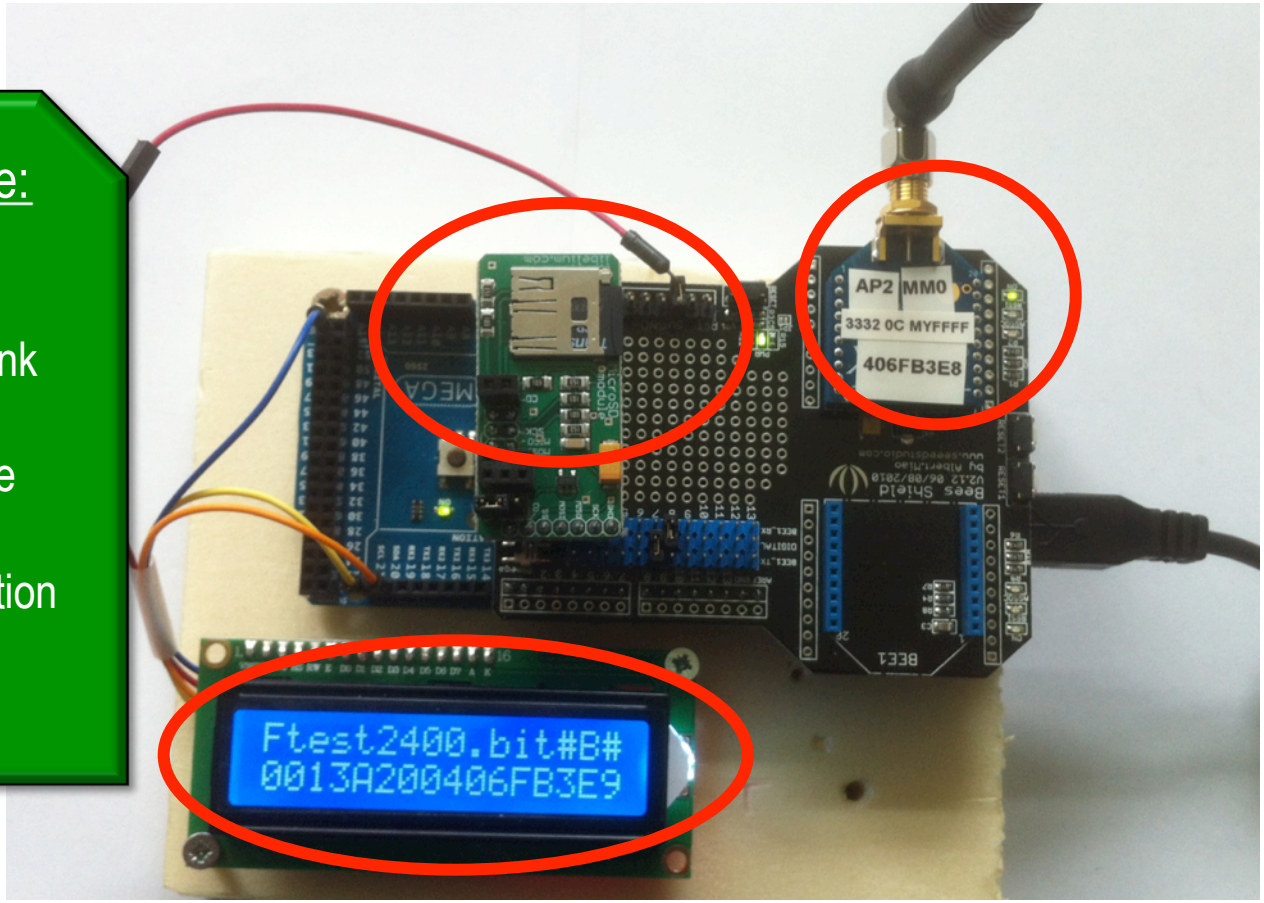


iMote2 with IMB400 multimedia board

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

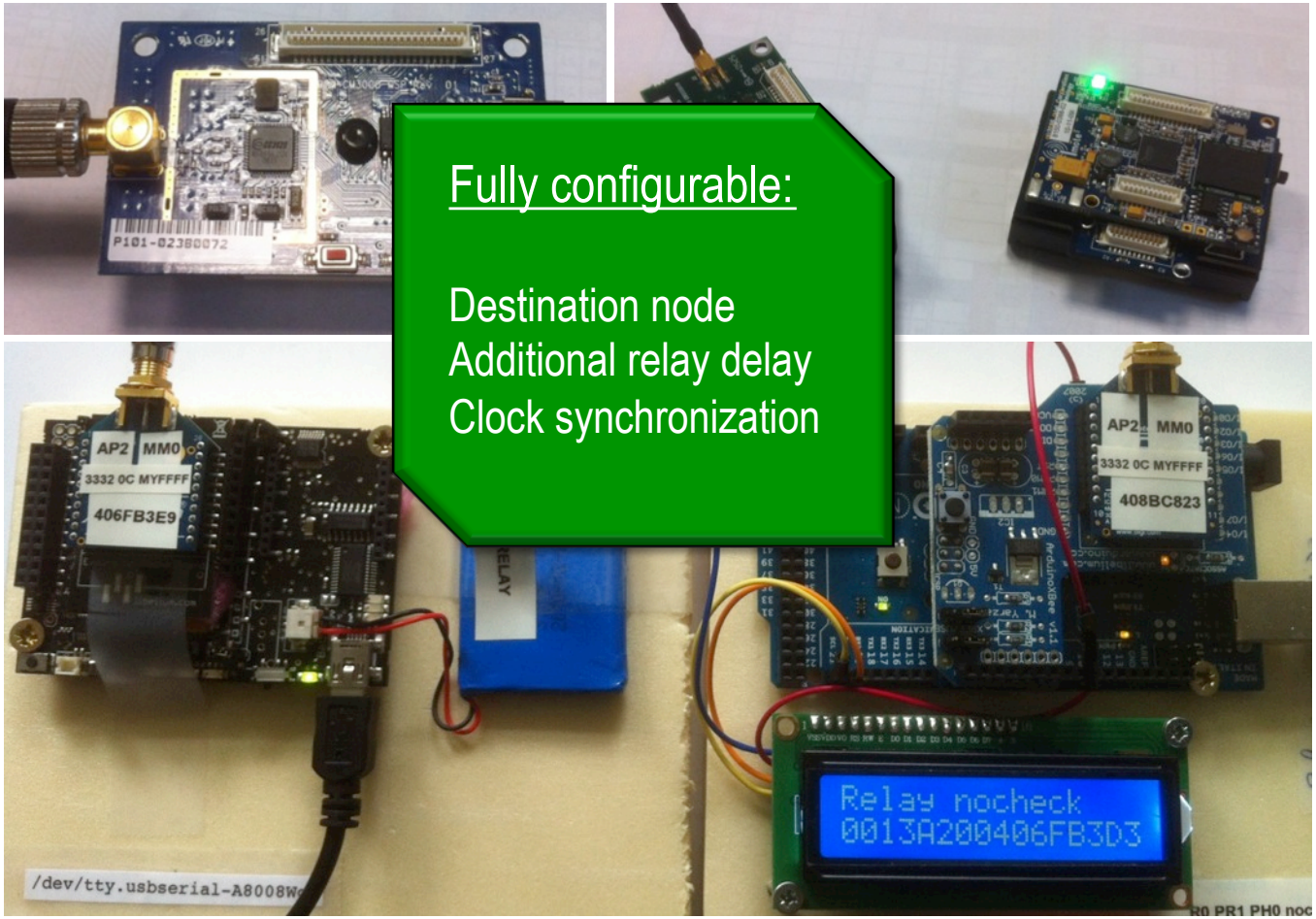


Cost: ~132€

Relay nodes

AdvanticSys TelosB

MicaZ and iMote2



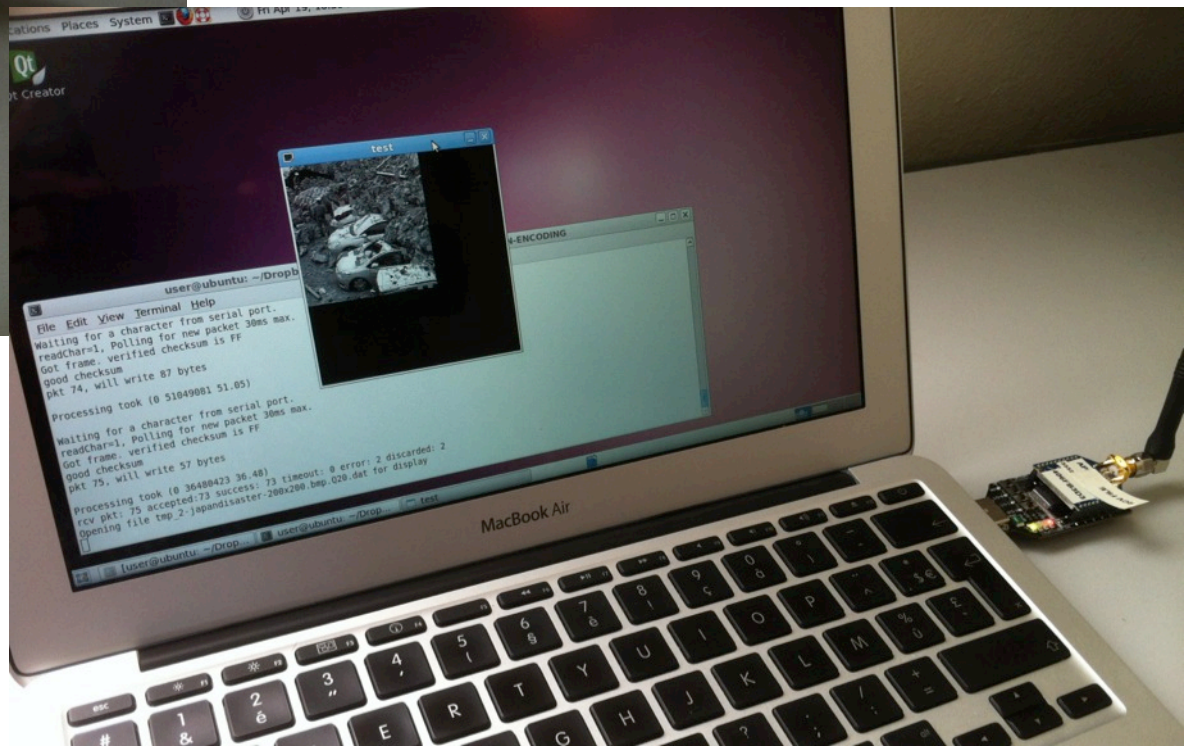
Libelium WaspMote

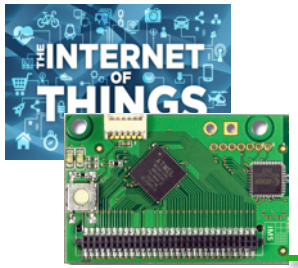
Arduino Mega2560

Sink node

Cost:
~42€

Linux PC/Laptop with
USB/Serial gateway





Adjustable Quality Factor

200x200, suitable for Situation-Awareness

Original BMP 40000b

Q=50 S=11045b 142pkts

PSNR=25

Q=40 S=9701b 123pkts

Q=30 S=8100b 101pkts

PSNR=23.2264

Collaboration with CRAN laboratory, Nancy, France. Very robust image encoding techniques against packet losses

Q=20 S=6236b 76pkts

PSNR=22.1293

Q=15 S

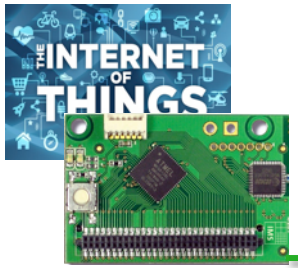
PSNR=21.4475

47pkts

PSNR=20.5255

Q=5 S=2053b 24pkts

PSNR=18.937



Transmission Time

Original BMP 40000b

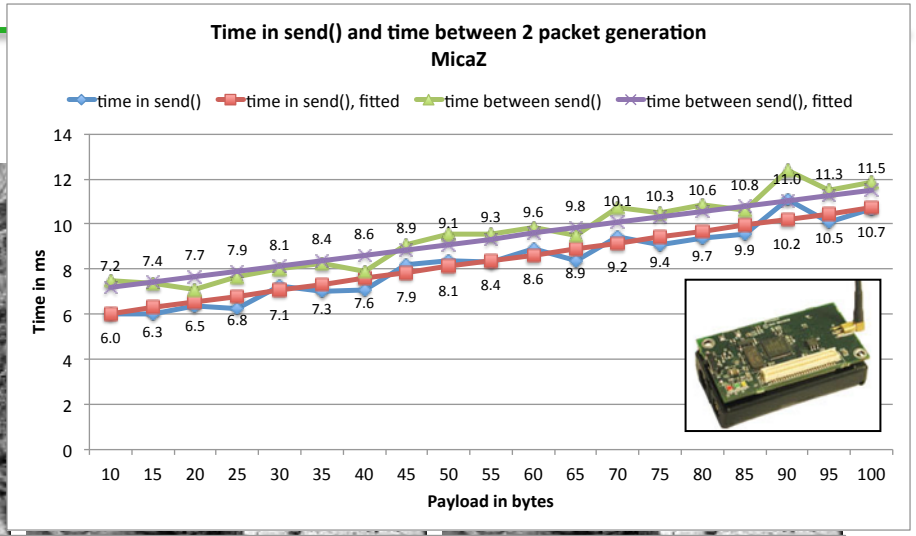
250kbps: 1.28s

400pkt of 100bytes:
400*0.0115=4.6s

Relay overhead:
400*0.0157=6.28s

Q=50 S=11045b 142pkts

PSNR=25.1661



Q=20 S=6236b 76pkts

250kbps: 0.199s

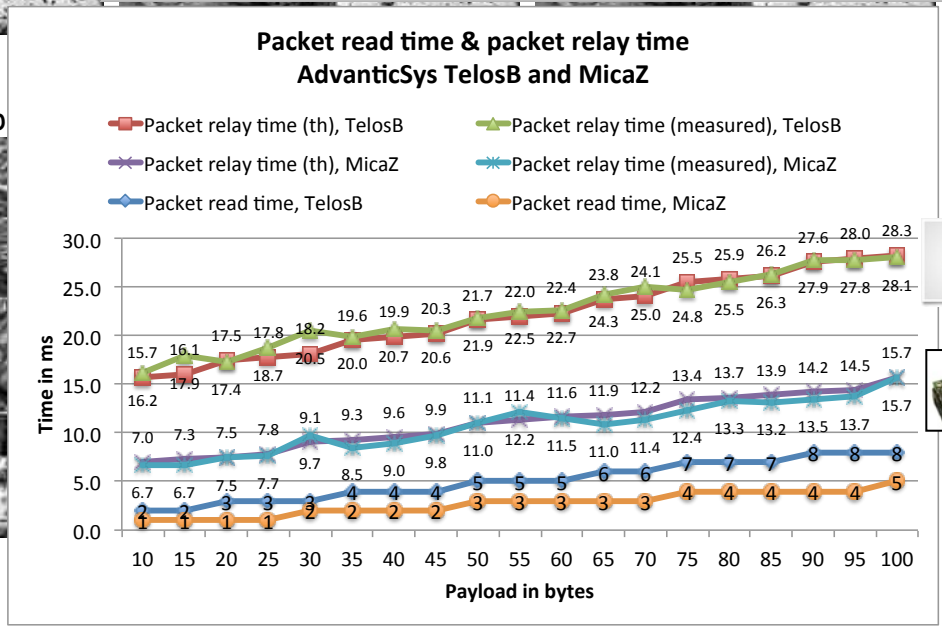
76pkt of 95bytes:
76*0.0113=0.858s

Relay overhead:
76*0.0145=1.102s

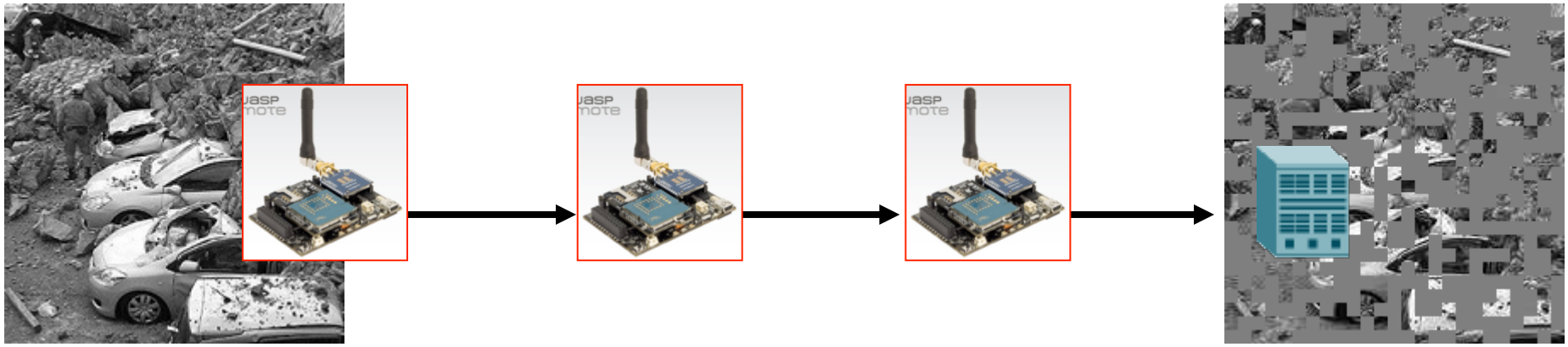
PSNR=22.1293

Q=15 S=5188b 63p

PSNR=21.4475



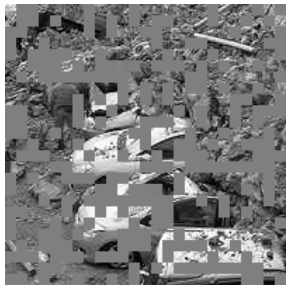
Multi-hop forwarding increases pkt loss rate




10%


20%


30%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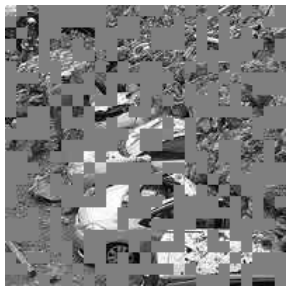
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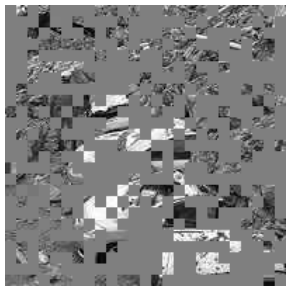
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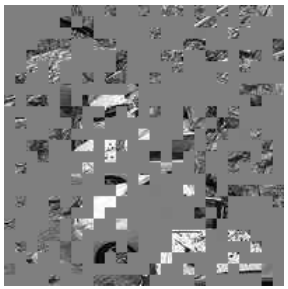
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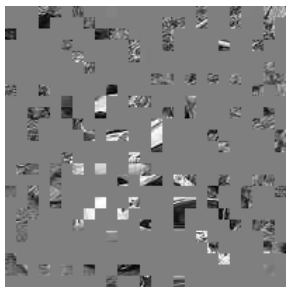
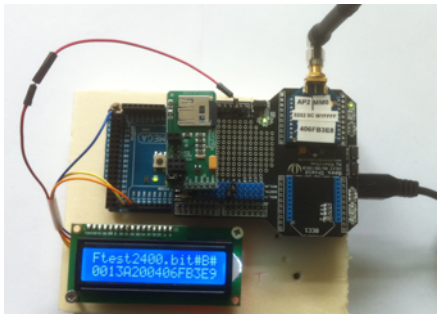
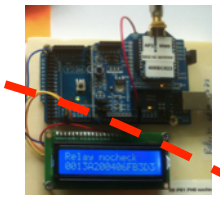
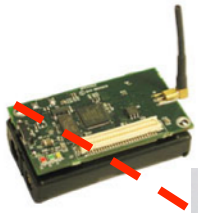

80%

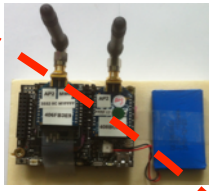
Test bed

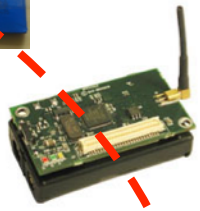
R0/1 enable/disable relay mode
D0013A2004086D828 set the 64-bit dest. mac addr
D0080 set the 16-bit dest. mac addr











XBeeReceive Unix tool

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:

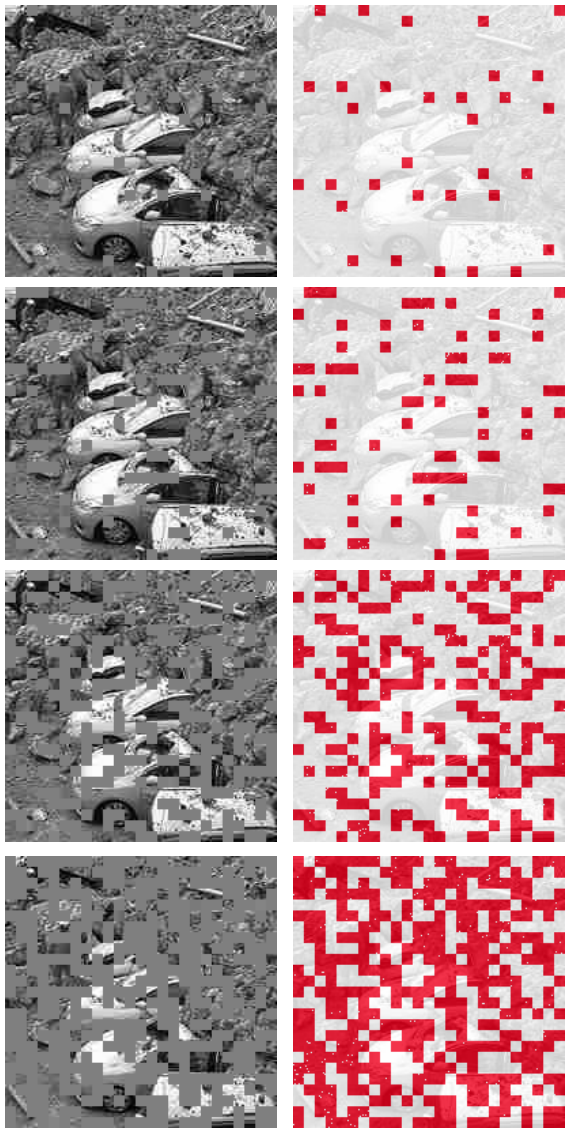
/@T130#, /@FjapanQ20.dat#I#

IMAGE RECEPTION QUALITY

200x200
76 PKTS

ARDUINO MEGA2560

ARDUINO MEGA2560

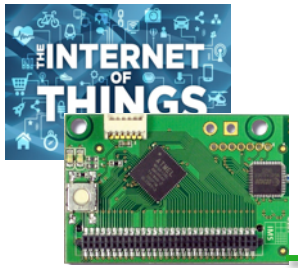


80ms
PSNR=26.2259

70ms
PSNR=21.9901

60ms
PSNR=17.265

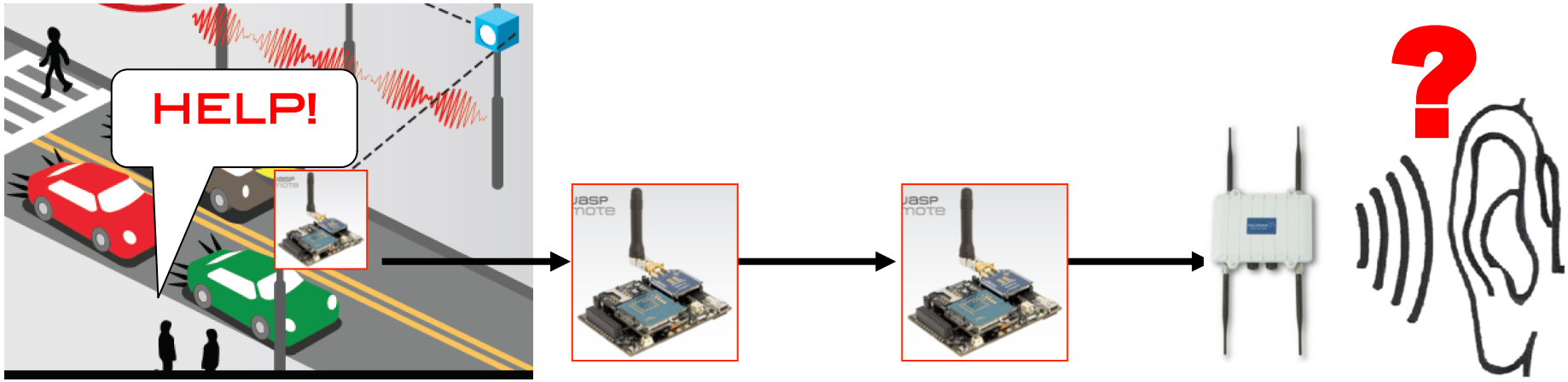
50ms
PSNR=14.2429

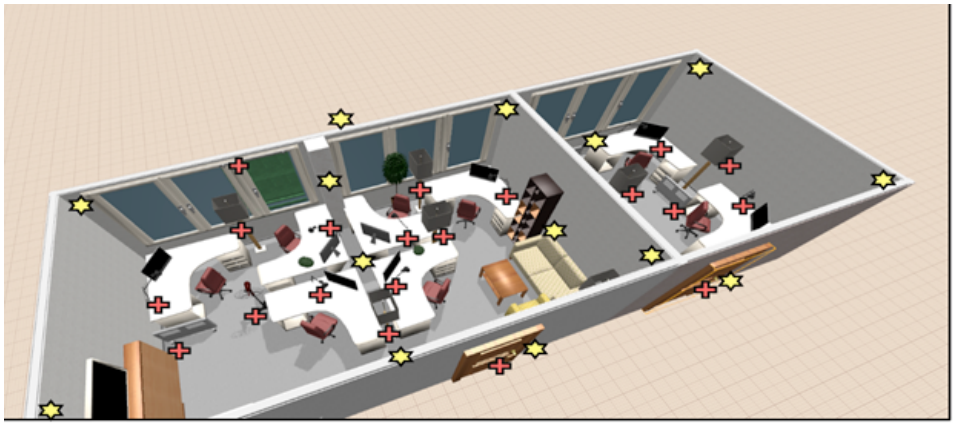


Some contributions « from theory to practice »

Image and acoustic for surveillance

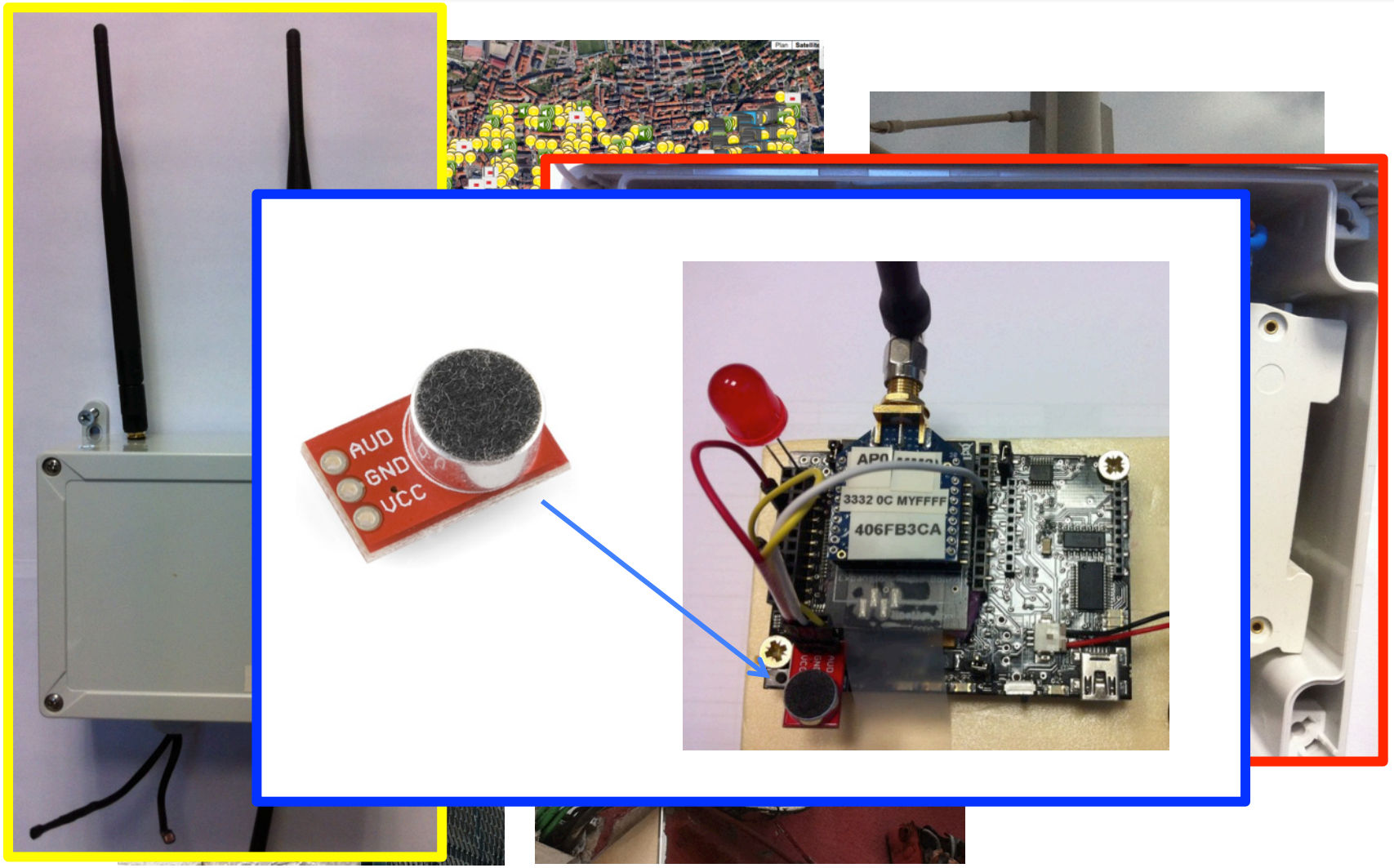
EAR-IT: audio surveillance in SmartCities and SmartBuildings



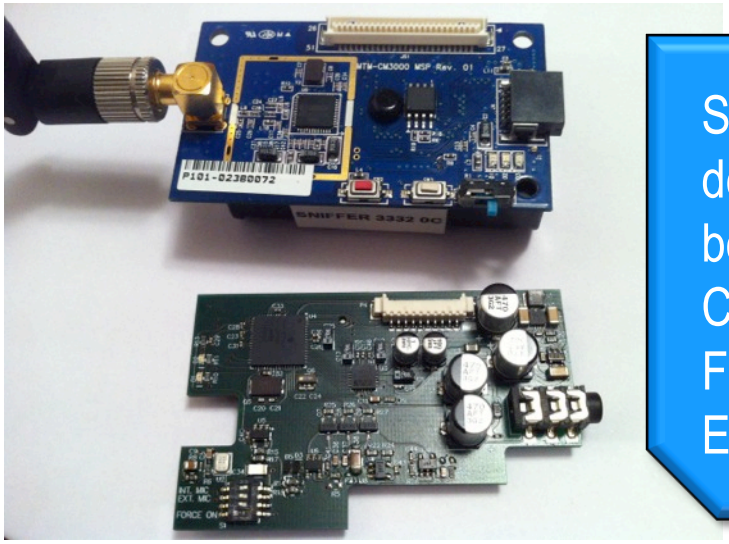


See http://www.ear-it.eu

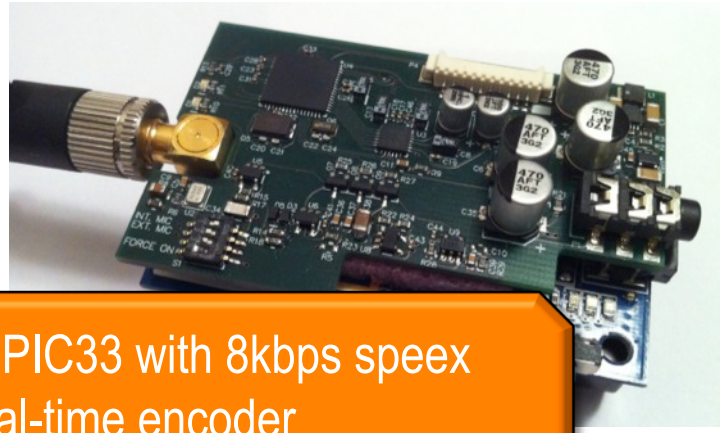
EAR-IT on SmartSantander



EAR-IT on HobNet test-bed at UNIGE



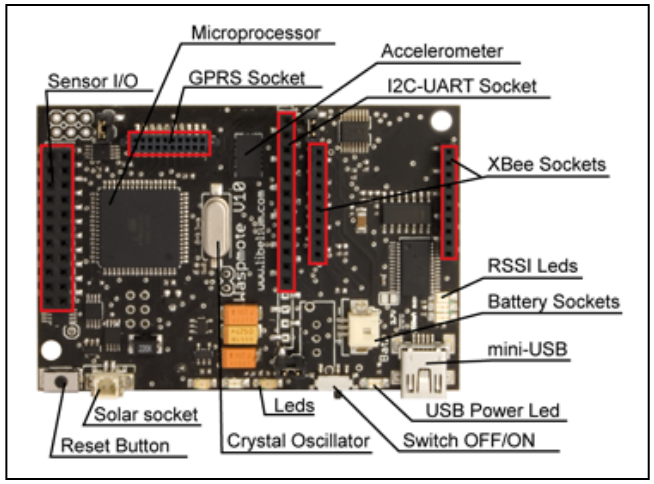
Specially designed audio board by INRIA CAIRNS & Feichter Electronics



dsPIC33 with 8kbps speex real-time encoder

EAR-IT IoT node

libelium
comunicaciones inalámbricas distribuidas



WaspMote

8MHz Atmega1281
8kB SRAM, 128kB Flash
Xbee radio

advanticsys

AdvanticSys CM5000
TelosB-like mote

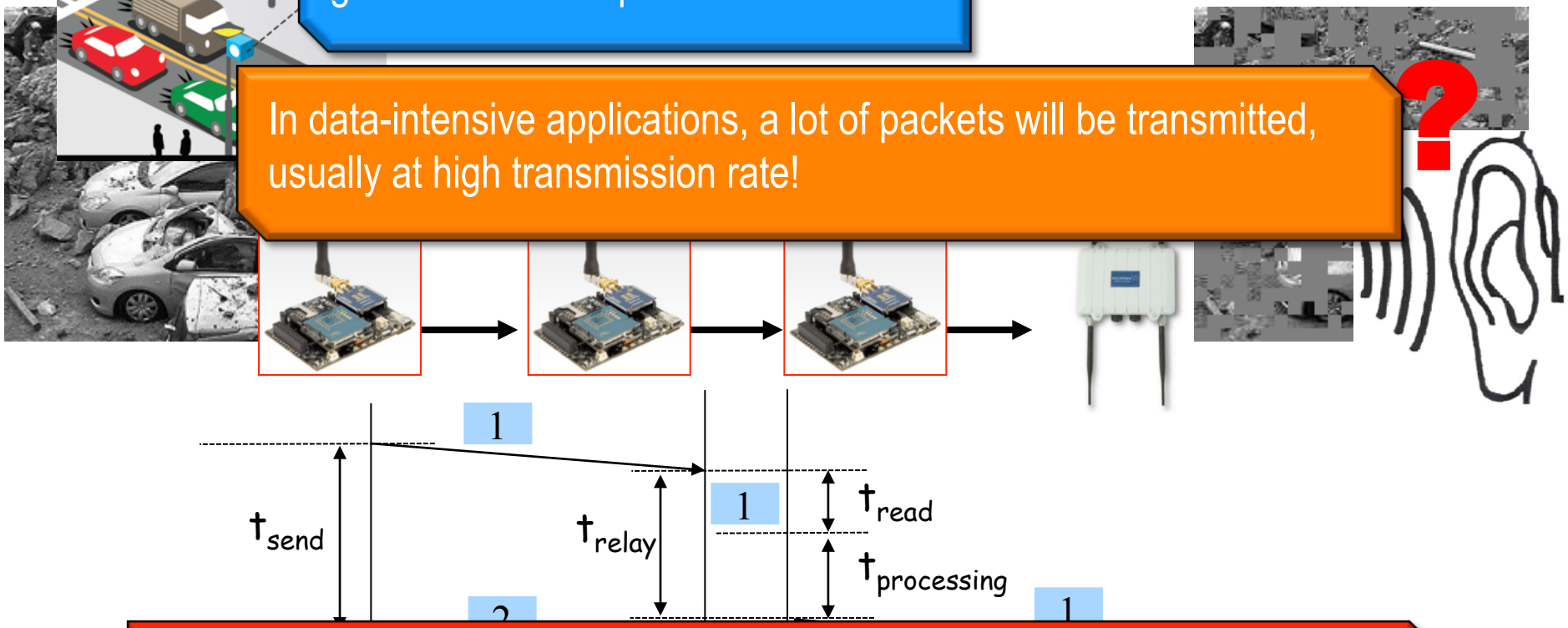
8Mhz MSP430F1611
48K flash, 10K RAM
CC2420 radio

IMAGES ARE FROM LIBELIUM COMPANY

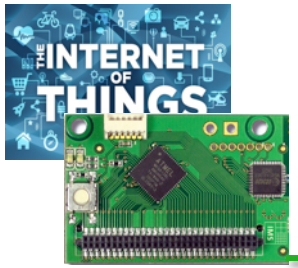
Multi-Hop Packet Forwarding

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

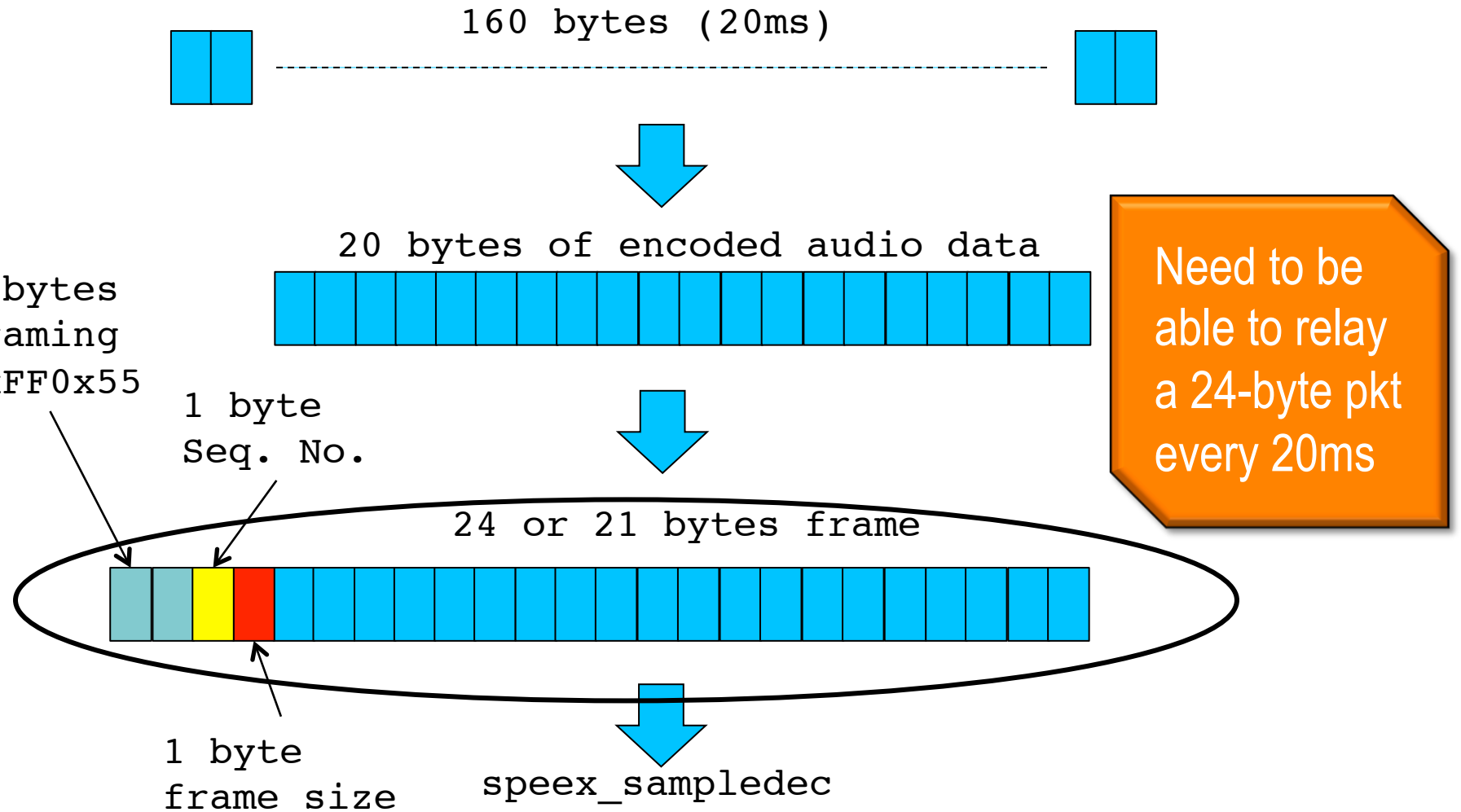
In data-intensive applications, a lot of packets will be transmitted, usually at high transmission rate!

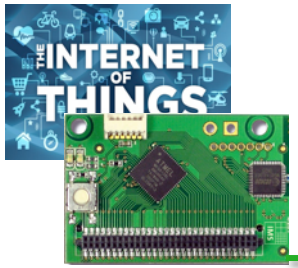


What level of performances can we expect?

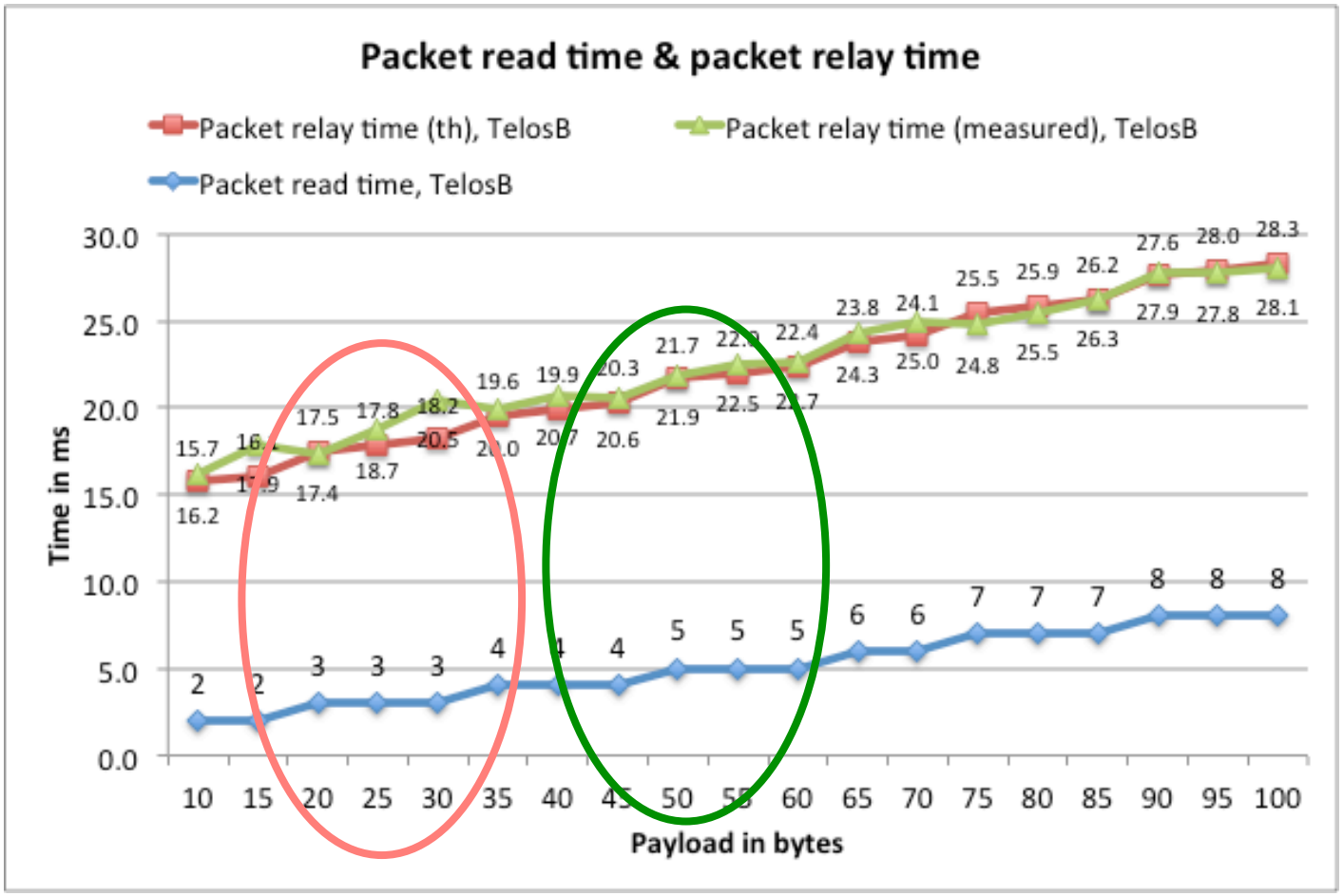


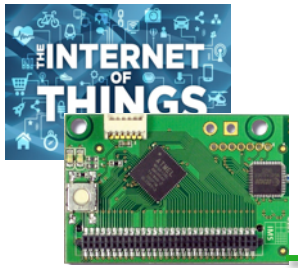
SPEEX AT 8KBPS REQUIREMENTS



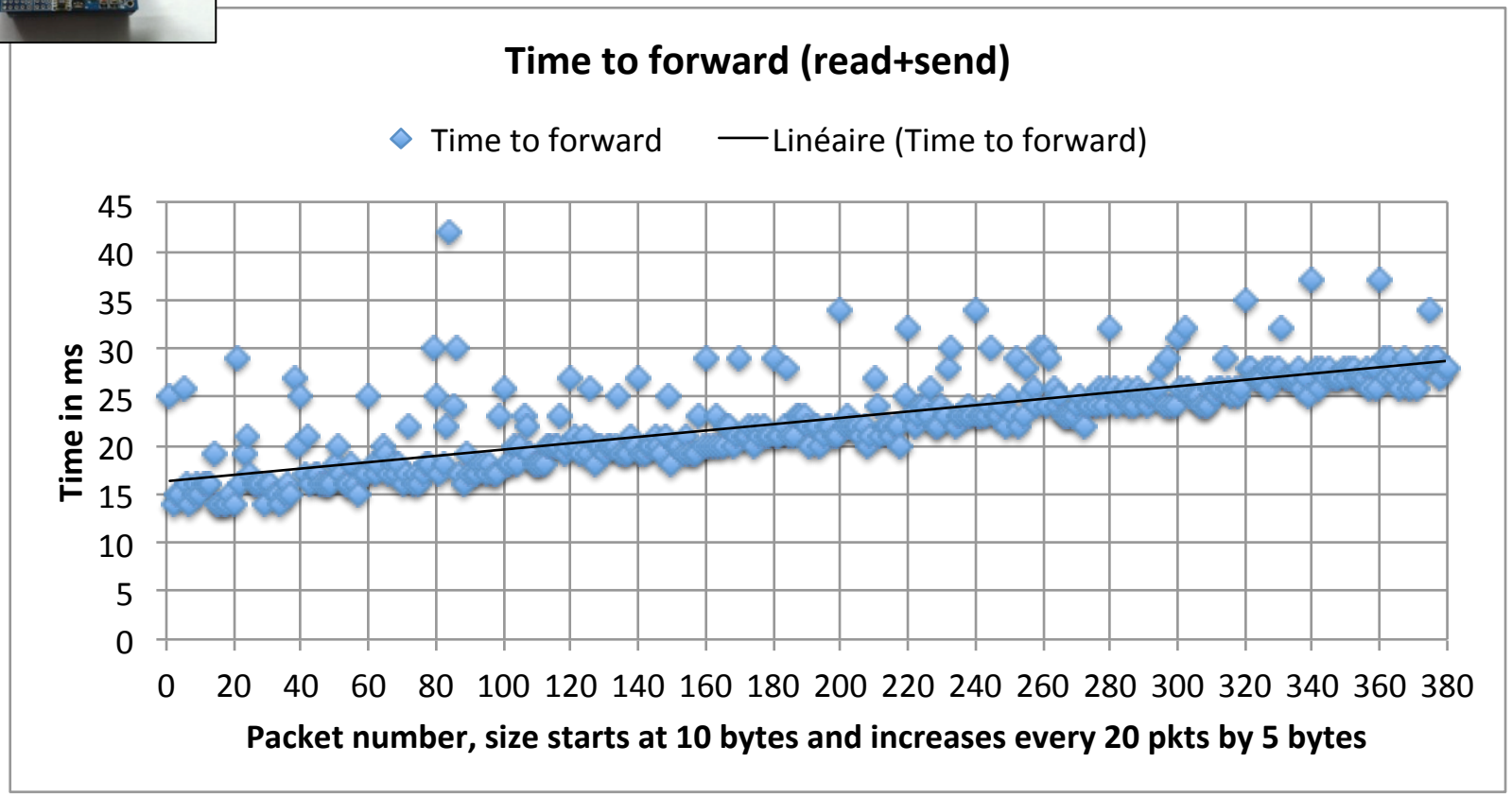


Relay node performances





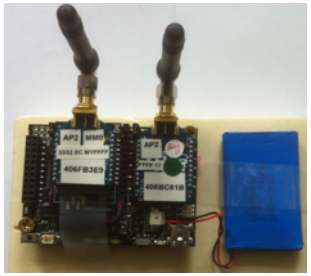
« Time to forward » measures

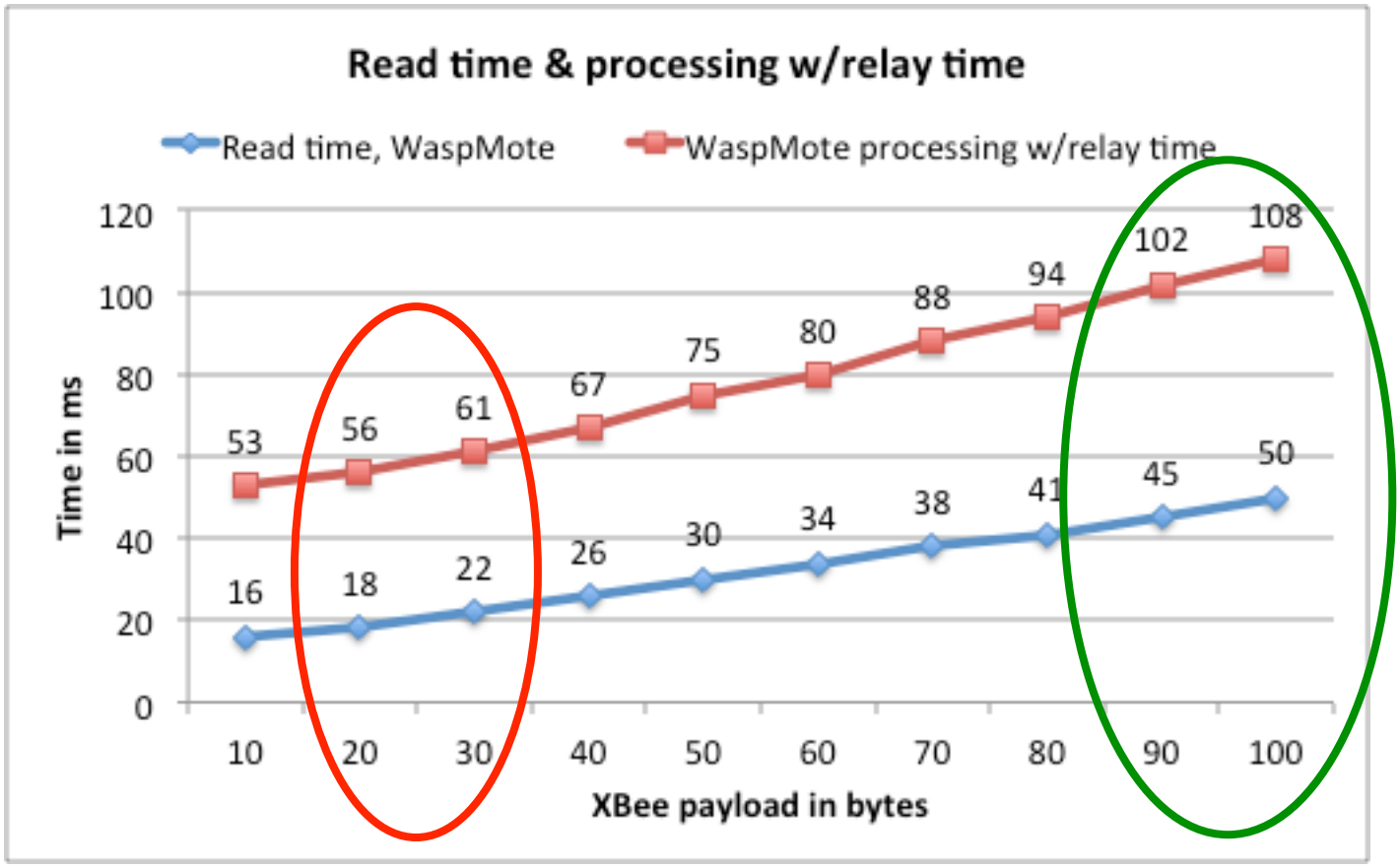


Test on SmartSantander

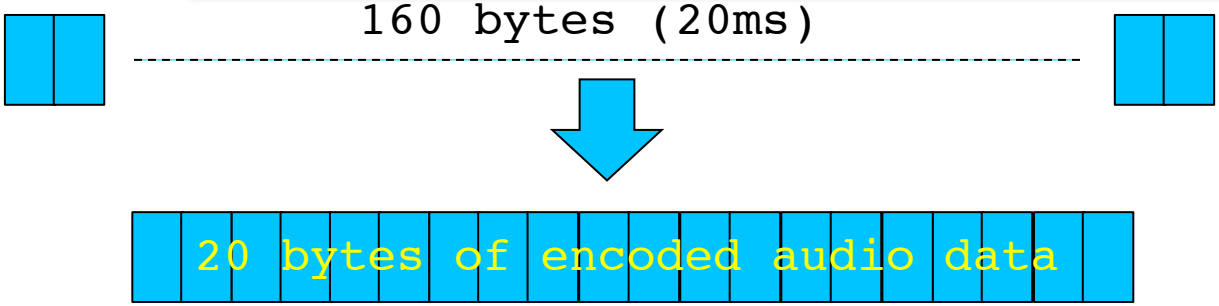
Test on SmartSantander

Relay node performances

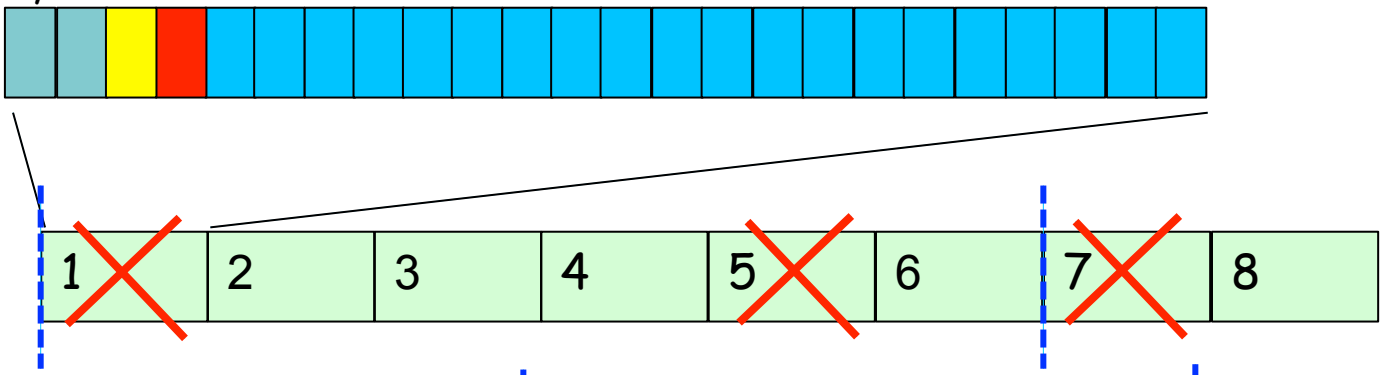


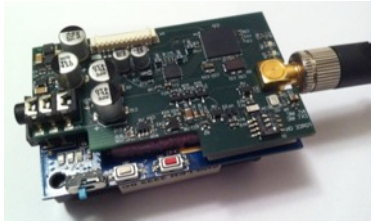


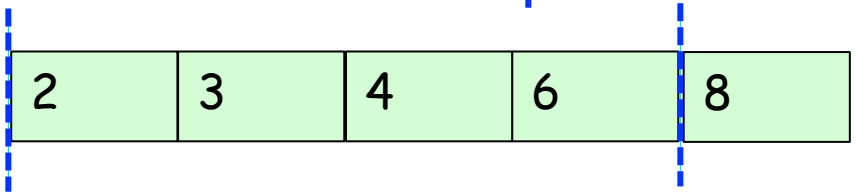
SPEEX AT 8KBPS ON SLOW RELAY NODES



Add framing bytes



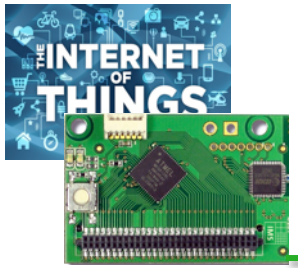




A6 aggregate audio frames

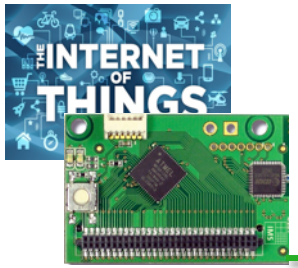
Capture 6 audio frames (120ms) but only send 4

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



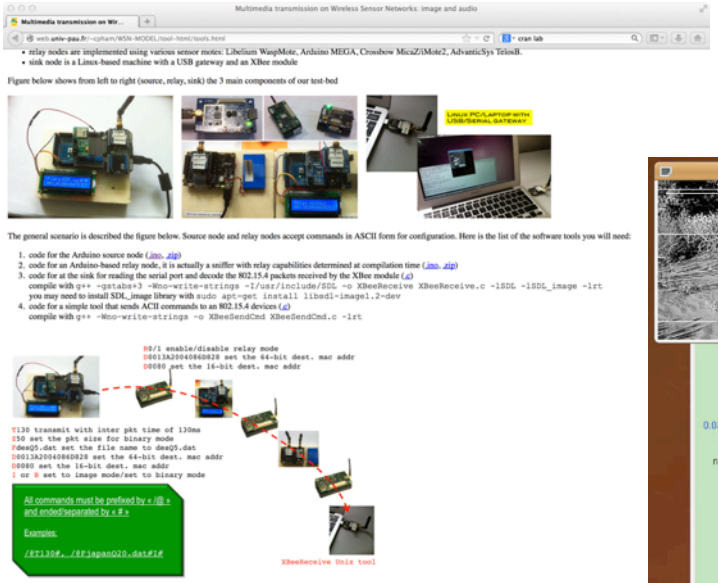
Conclusions

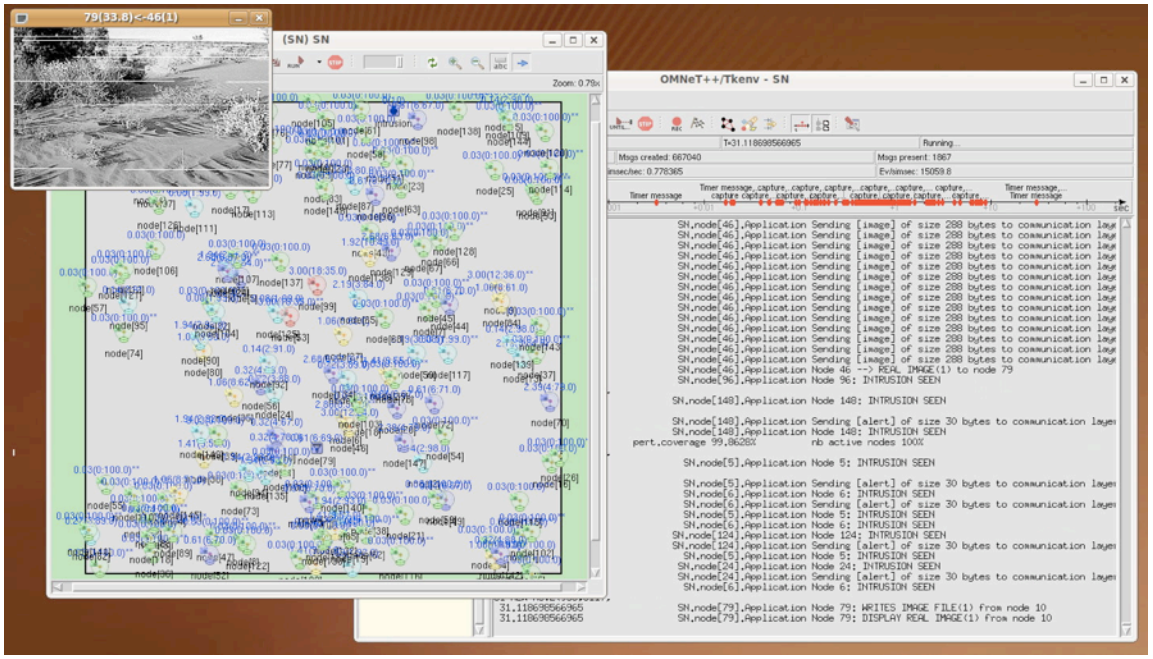
- Wireless communication can now be integrated at low-cost to a number of small devices/objects
- Sensor Networks can provide large scale awareness to setup the foundation for AMBIENT INTELLIGENCE to offer new services for SMART SOCIETIES
- Hot topics are multimedia information for enhanced situation-awareness
- Testbed & real experimentations are needed to highlight realistic issues
- Our research is on proposing suitable control mechanisms based on realistic constraints



Some links

http://web.univ-pau.fr/~cpham/WSN-MODEL/tool-html/tools.html





http://web.univ-pau.fr/~cpham/WSN-MODEL/wvsn-castalia.html