CARI'2014 TUTORIAL

Image and audio transmission on heterogeneous wireless sensor networks

Part I - Introduction
Digital eco-system, Wireless sensor networks, Internet of Things

Part II
Images and Audio challenges

Part III
Demonstration

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Digital eco-system, Wireless sensor networks, Internet of Things

CARI 2014 tutorial - PART I
Gaston Berger University
October, 17th, 2014
Saint-Louis, Senegal

Prof. Congduc Pham
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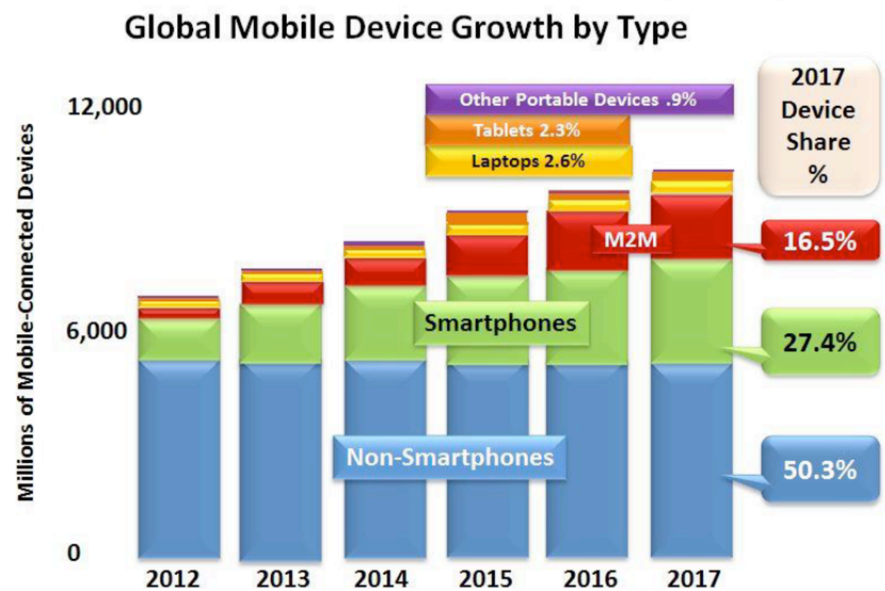
Université de Pau, France

Digital devices...

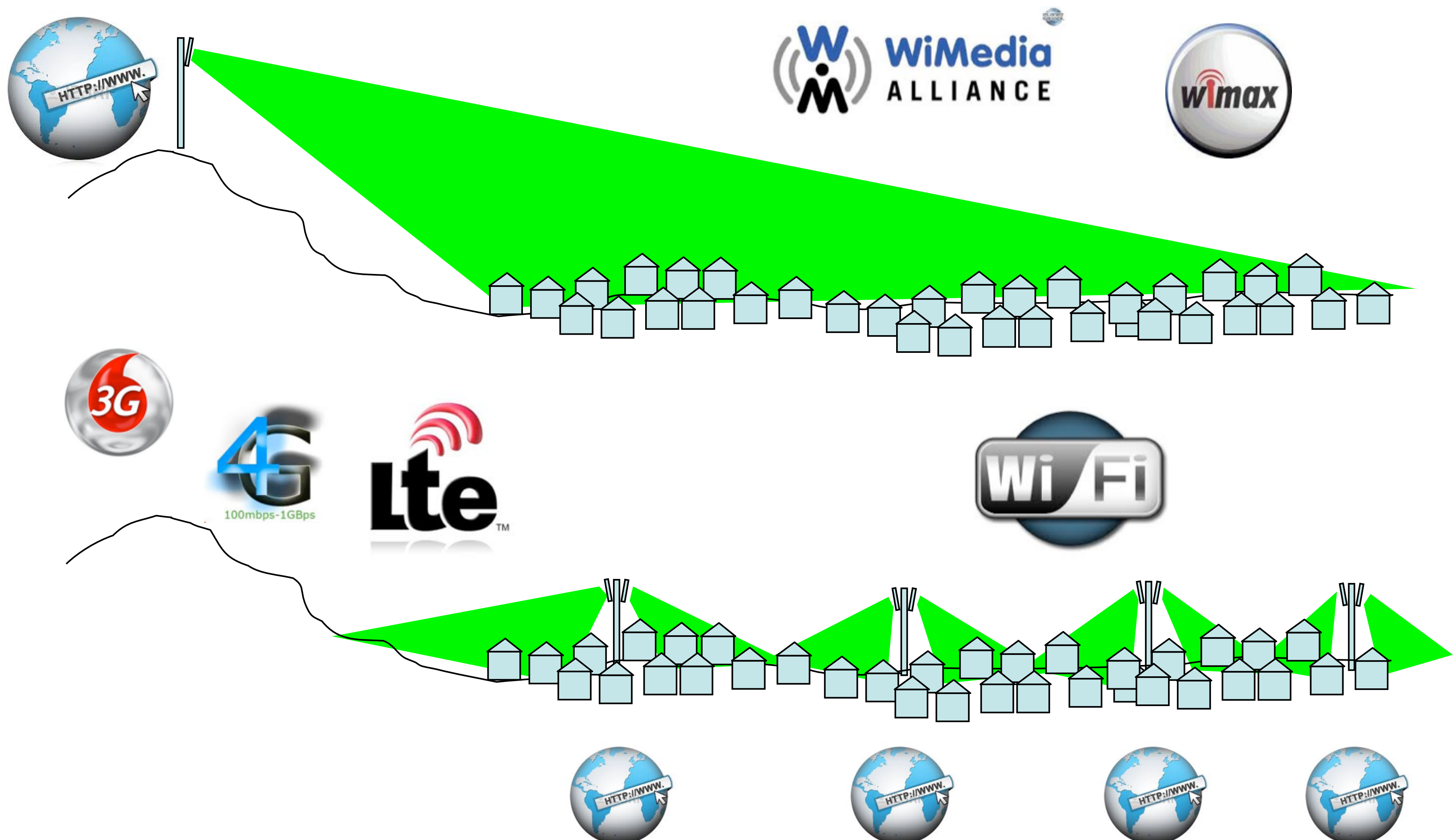
... AND WHY WE CALLED
IT AN ECOSYSTEM

Mobile devices

4G Americas / **4G Mobile Broadband Evolution: 3GPP Release 11 & Release 12 and Beyond** / February 2014



Cellular model



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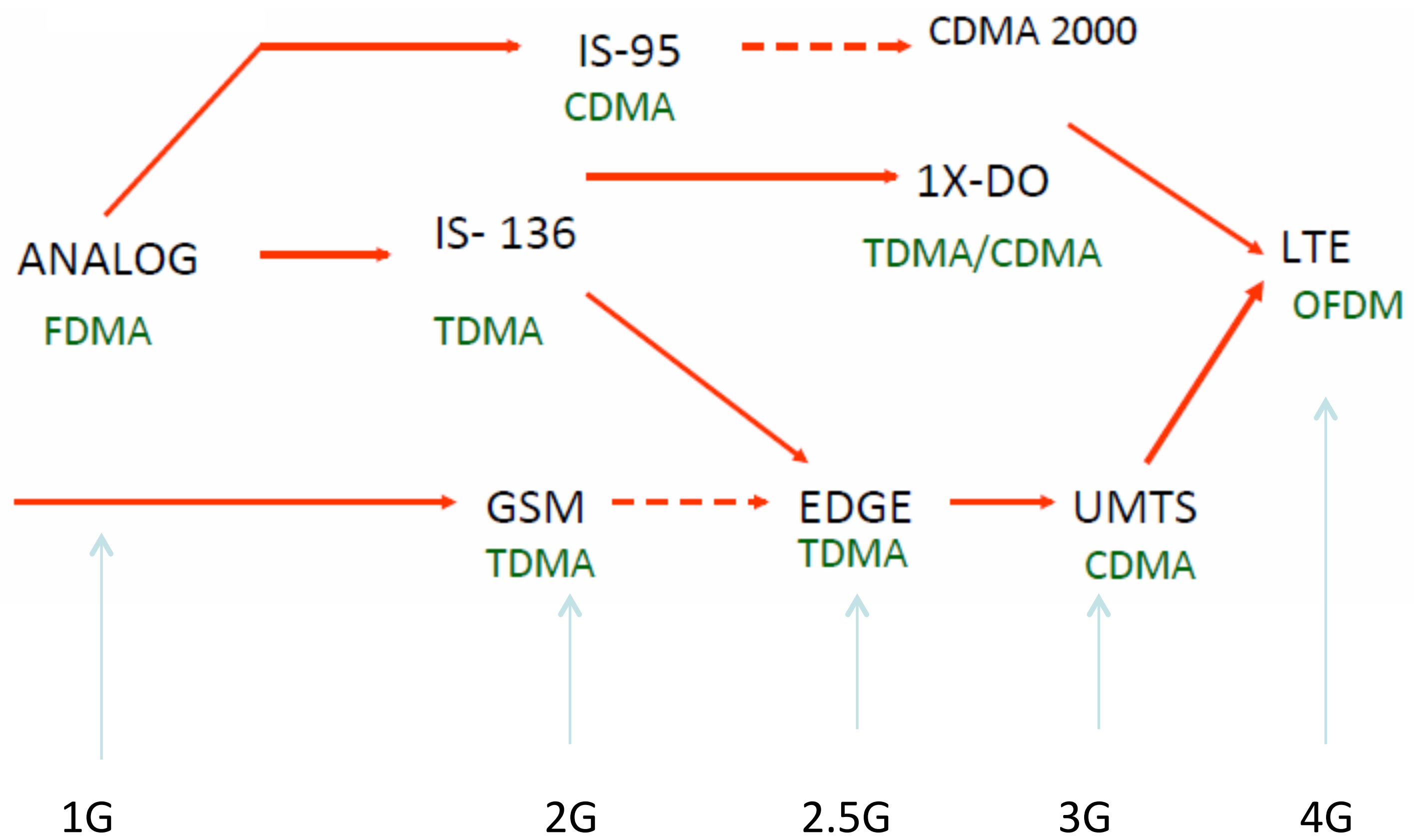
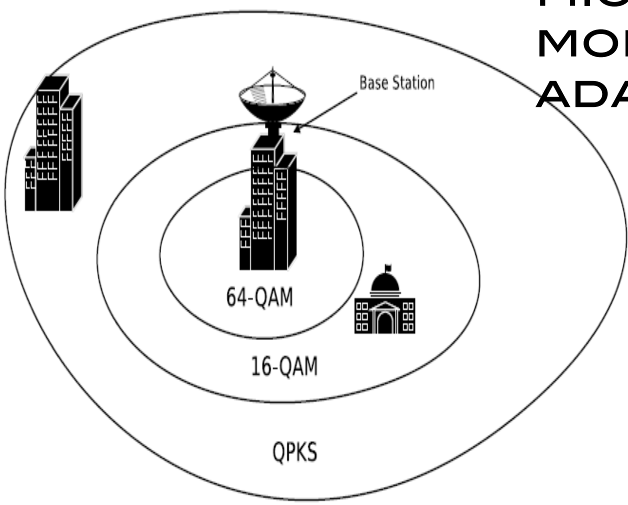
Evolution of Cellular Networks

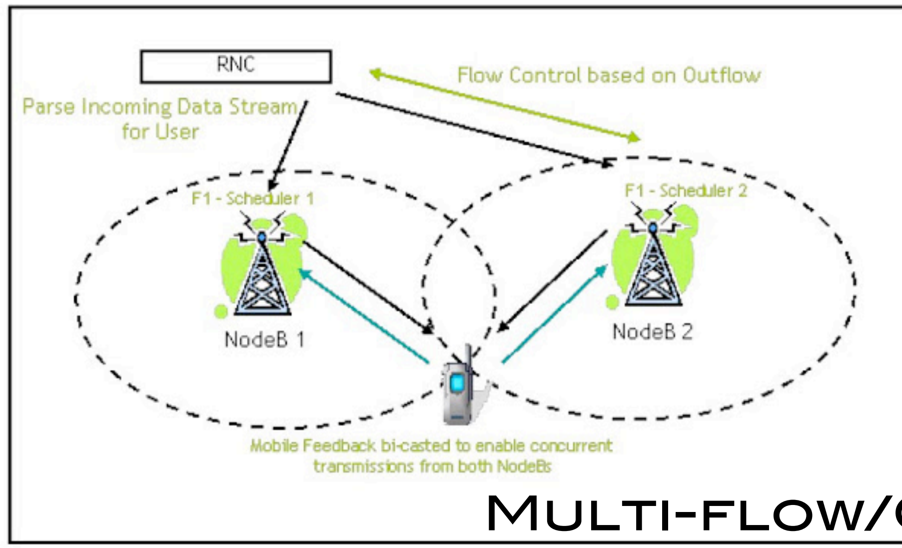


CDMAone->CDMA2000
EGDE: Enhanced Data Rates for GSM Evolution
UMTS:Universal Mobile Telecommunications System (W-CDMA)

(Some) Key Technologies

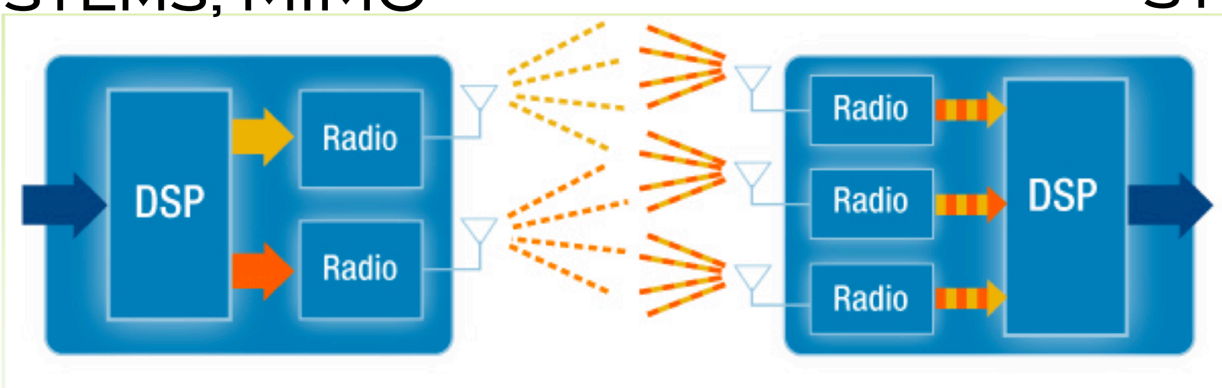
Higher order modulation and adaptive modulation



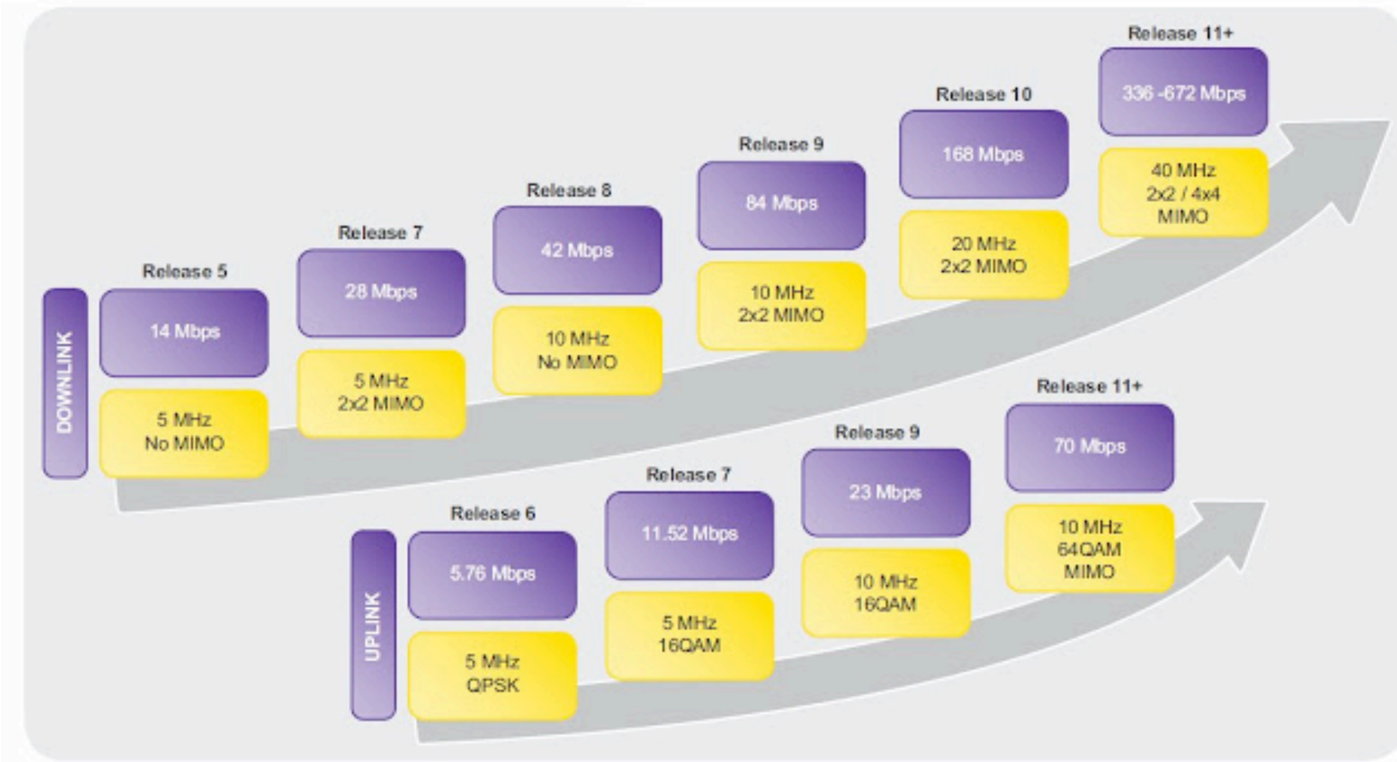


Multiple antenna systems, MIMO

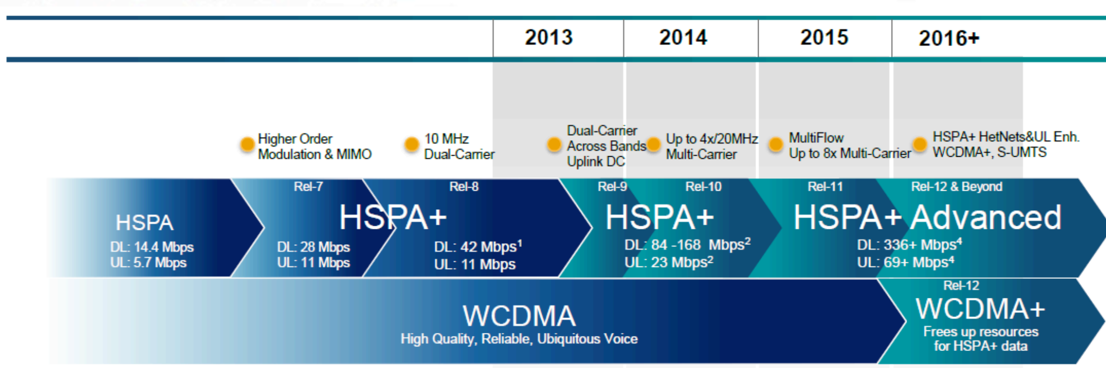
Multi-flow/Cell system



More throughput in near future!

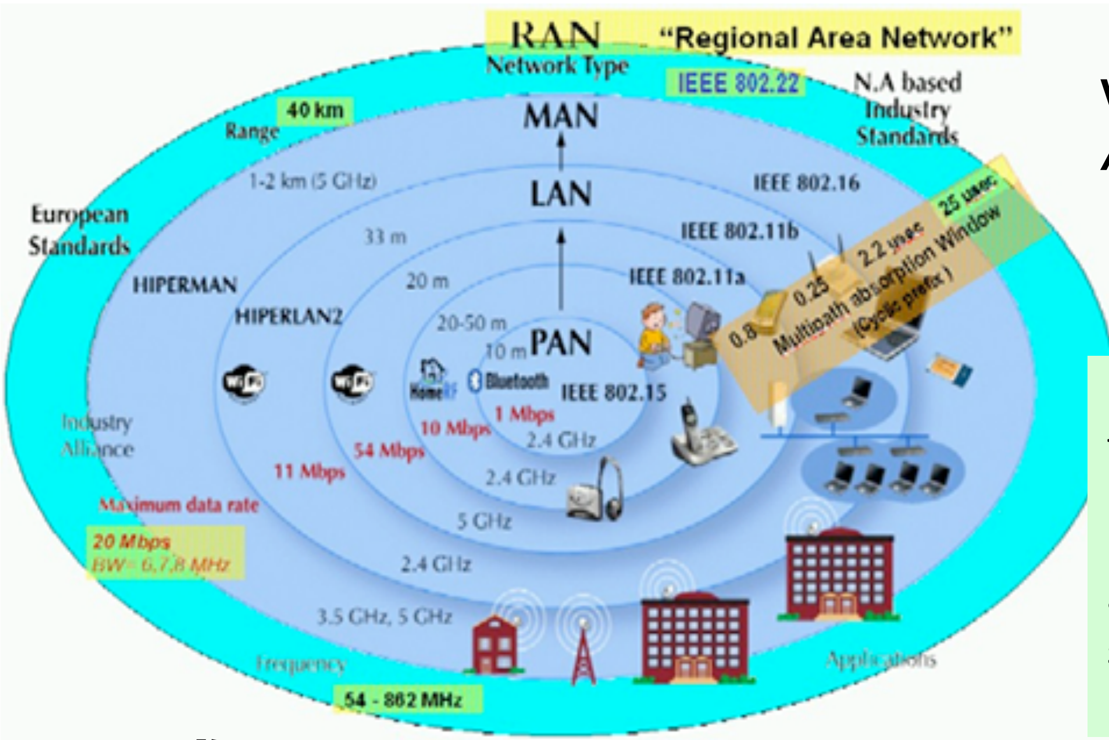


From NSN white paper on HSPA evolution



From QualComm

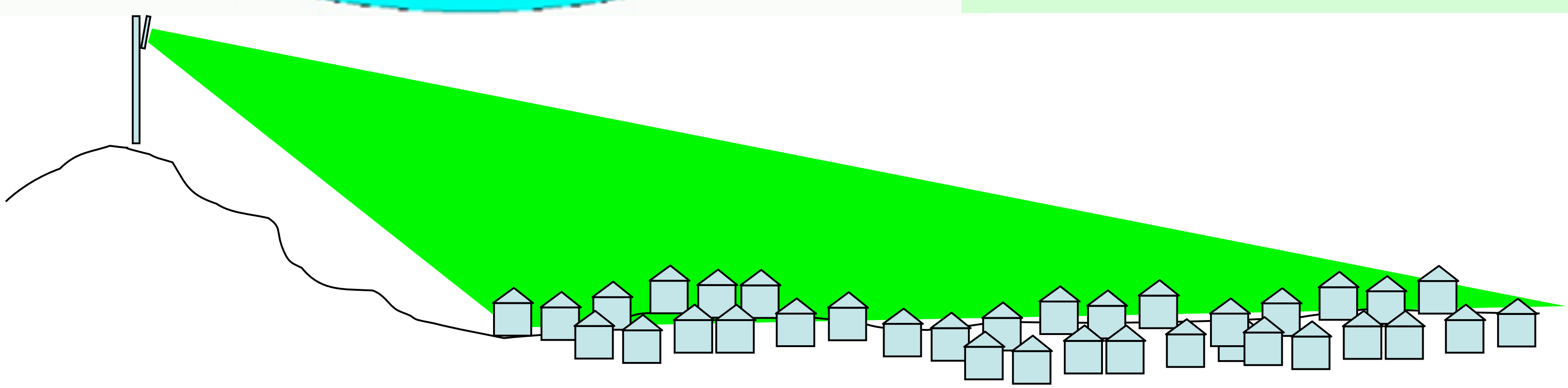
Towards 802.22 WRAN



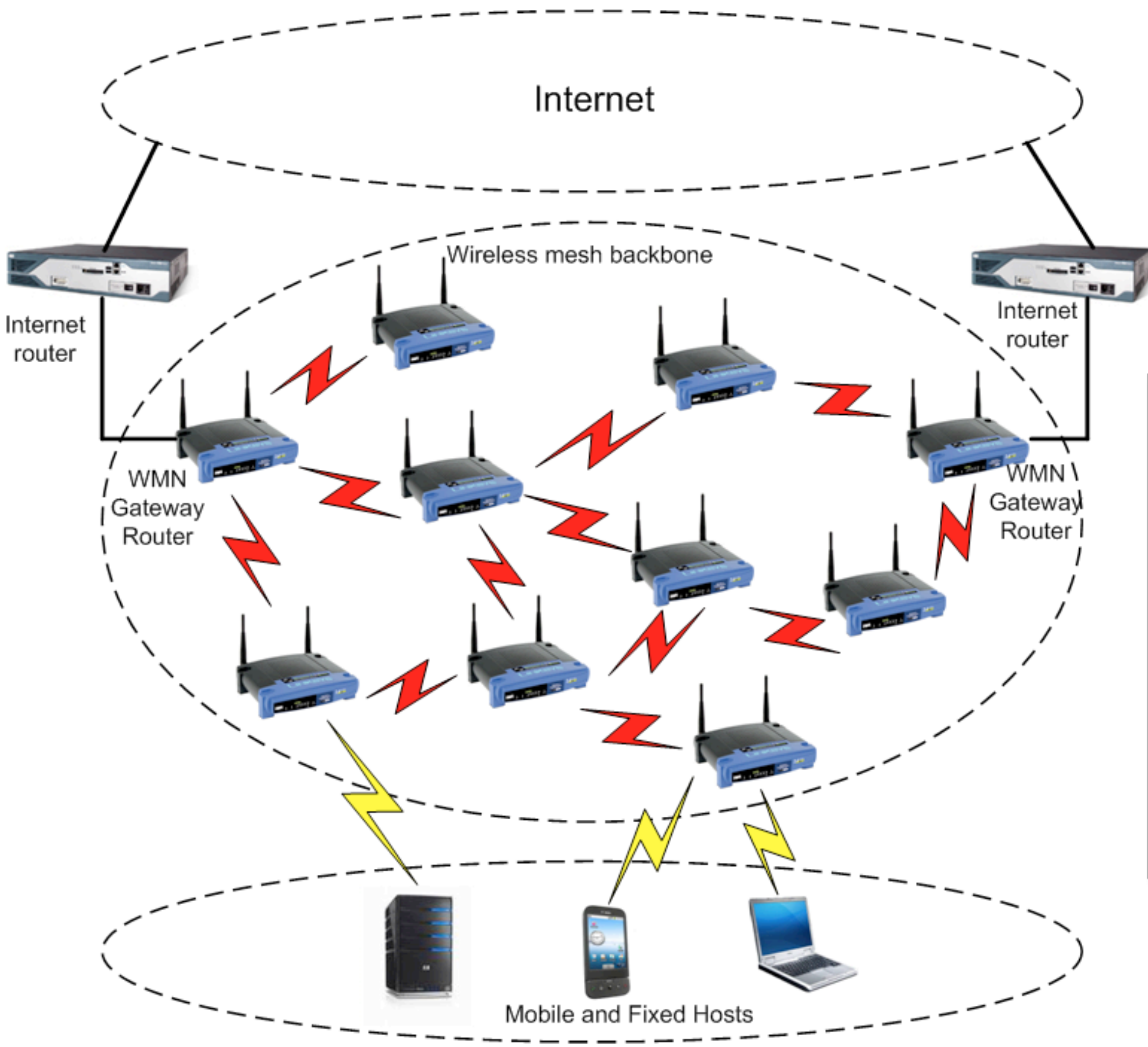
Wireless Regional Area Networks

uses white spaces in the television (TV) frequency spectrum.

using cognitive radio (CR) techniques to allow sharing of geographically unused spectrum allocated to the television broadcast service.



Cognitive radio wireless mesh networks



Cognitive, opportunistic, multi-channel radio for large-scale wireless infrastructures

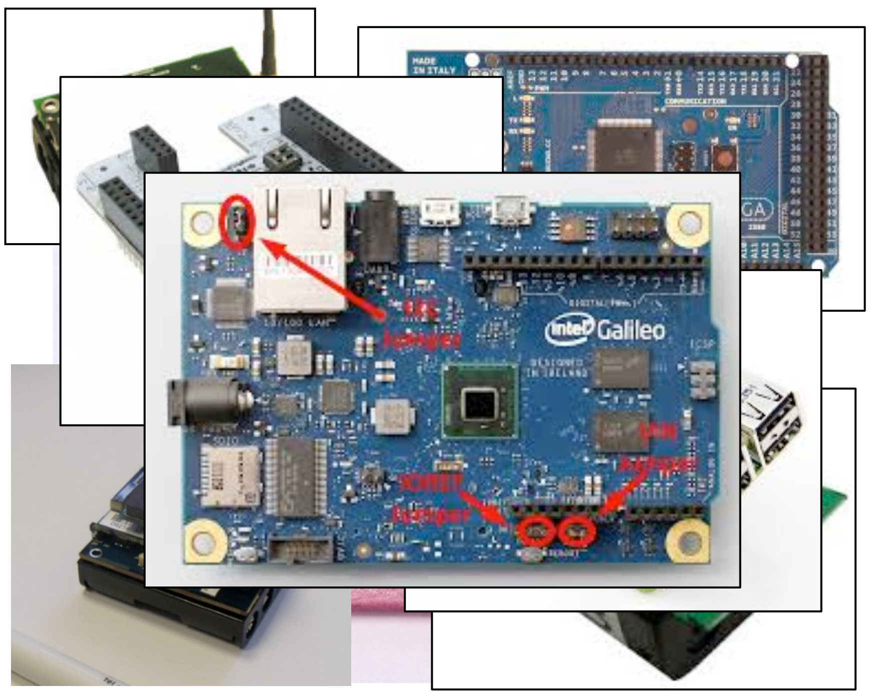
EVERYTHING, EVERYWHERE

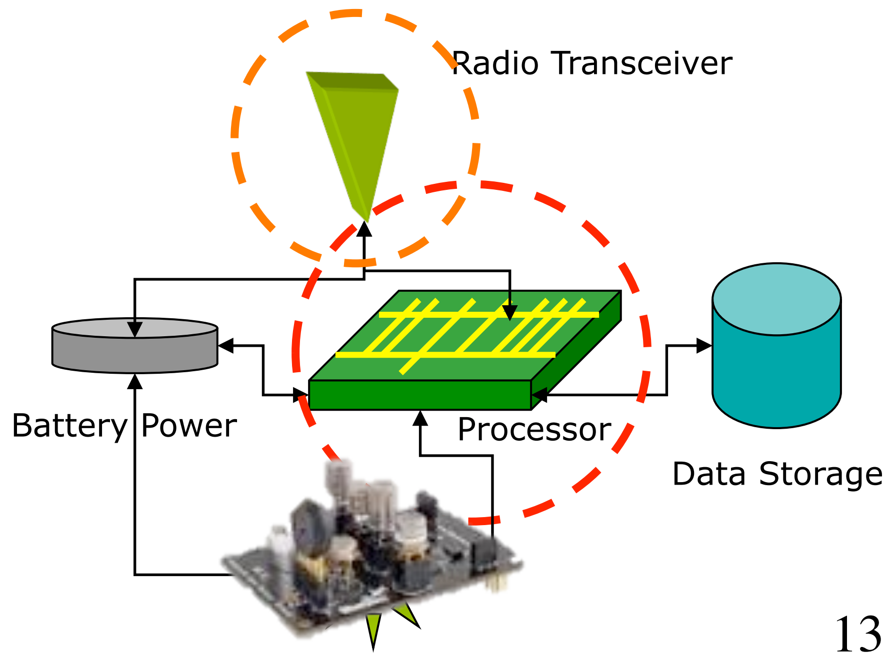
Take into account that in a near future, we will have more throughput with our mobile wireless devices than our wired home internet access

More digital devices!

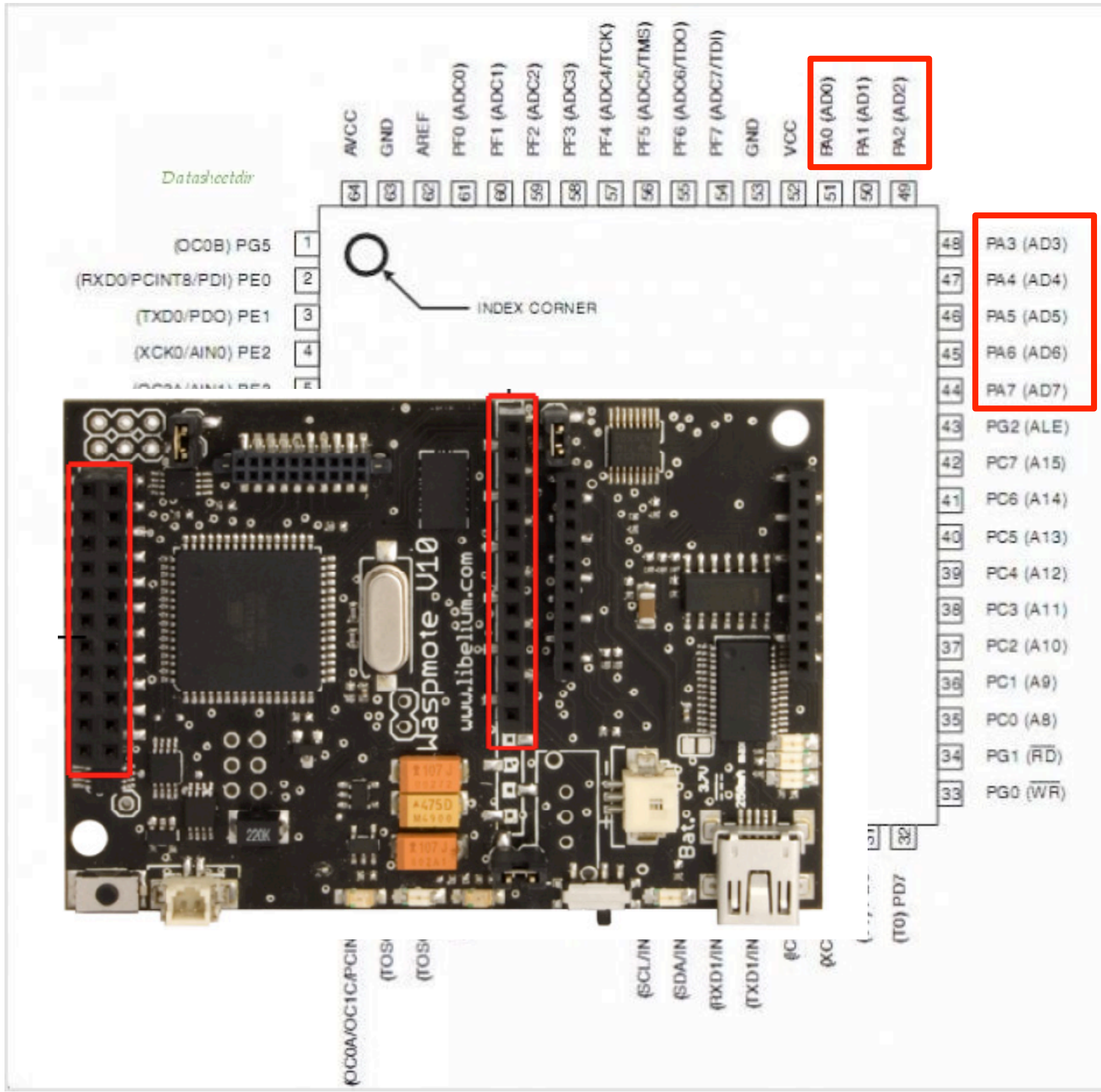
Wireless autonomous sensor

- Wireless Sensor Nodes or embedded Linux still remain the main IoT development platform
- In general: low cost, low power (the battery may not be replaceable), small size, prone to failure, possibly disposable





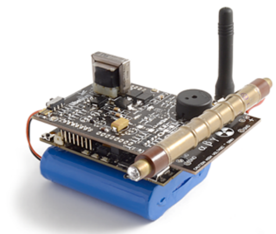
MICRO-CONTROLLER VS MICRO-PROCESSOR



Input voltage between 0 and Vref (e.g. 3.3V). ADC usually have 10-bit resolution:

0 is for 0V
1014 is for 3.3V

Beyond Sensor Networks: Communicating Objects!

- Native communication:  
- Added communication
  - Active communication

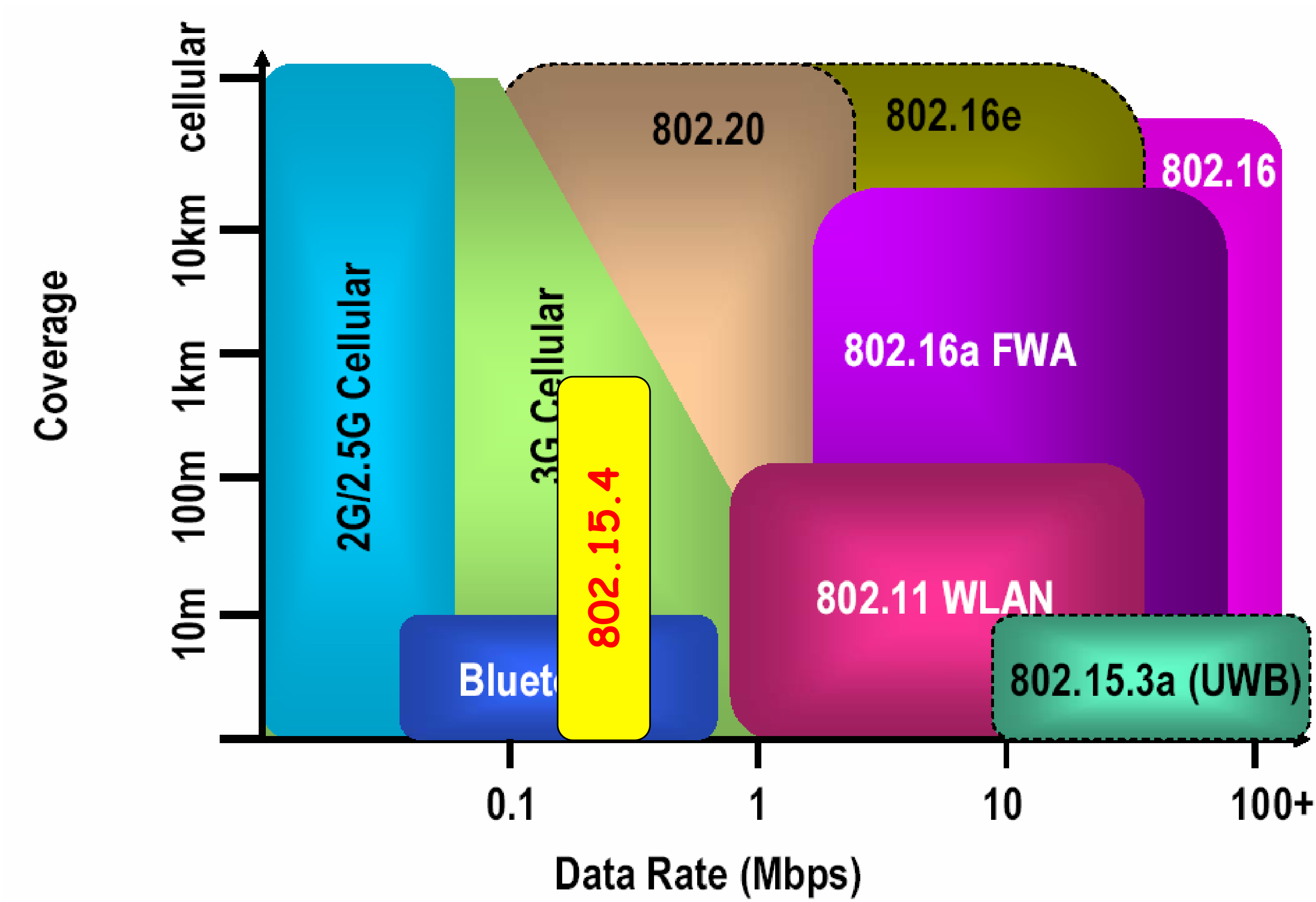




  - Passive communication

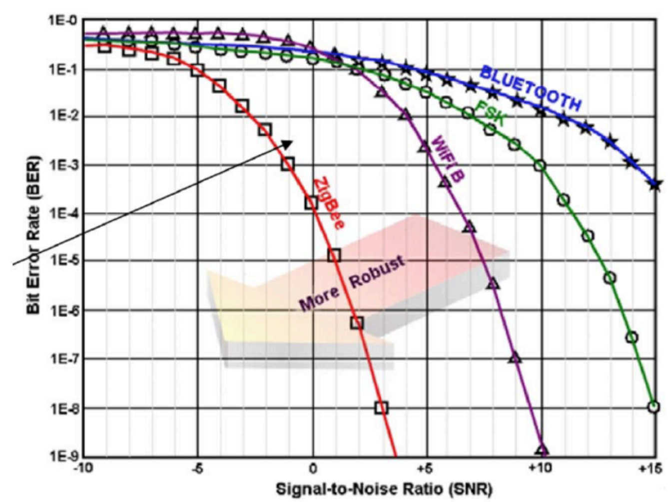
Wireless Communication made easy

Summary of Wireless technologies

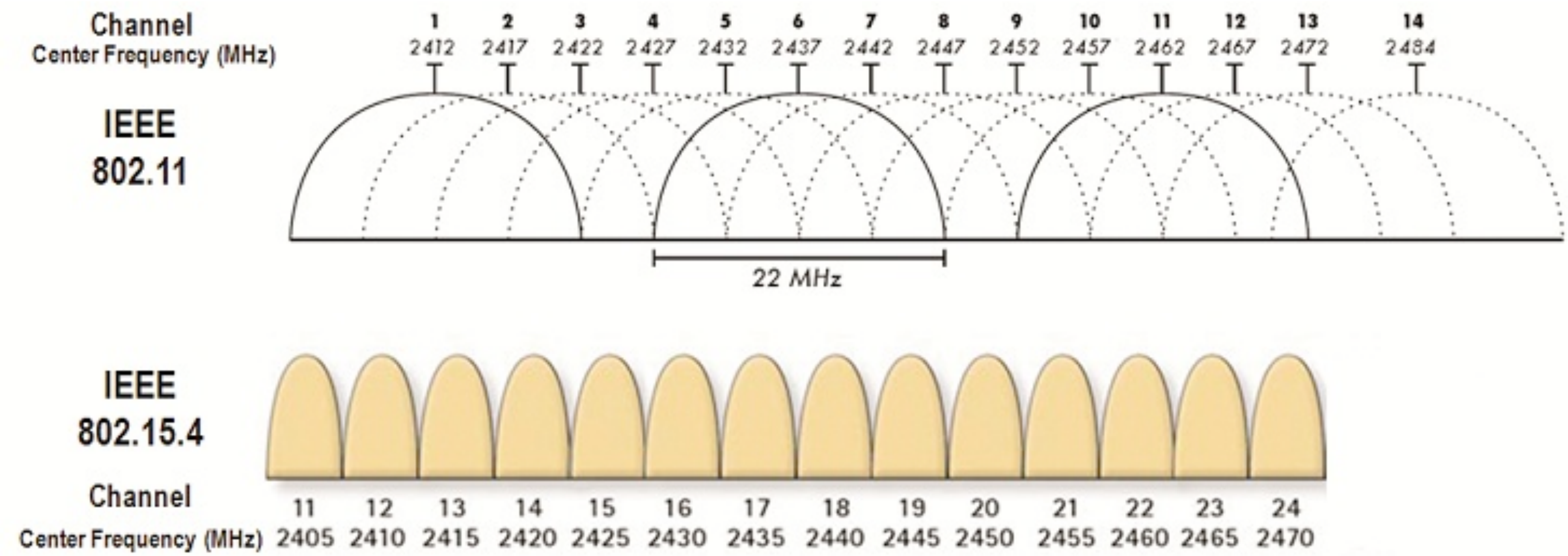


IEEE 802.15.4

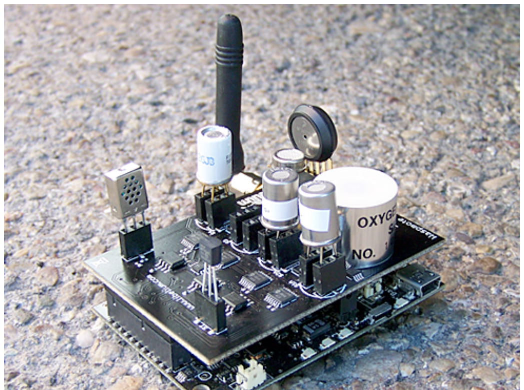
- Low-power radio in the 2.4GHz band offering 250kbps throughput at physical layer
- Power transmission from 1mW to 100mW for range from 100m to about 1km is LOS
- CSMA/CA (beacon & non beacon)
- Used as physical layer in ZigBee



Spectrum band



Energy consideration



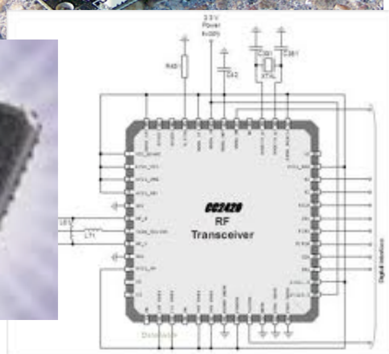
18720 Joules

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



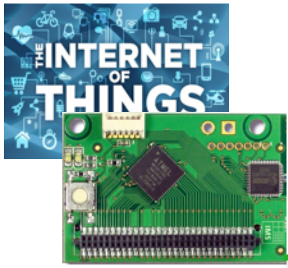
Chipcon Products from Texas Instruments

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	

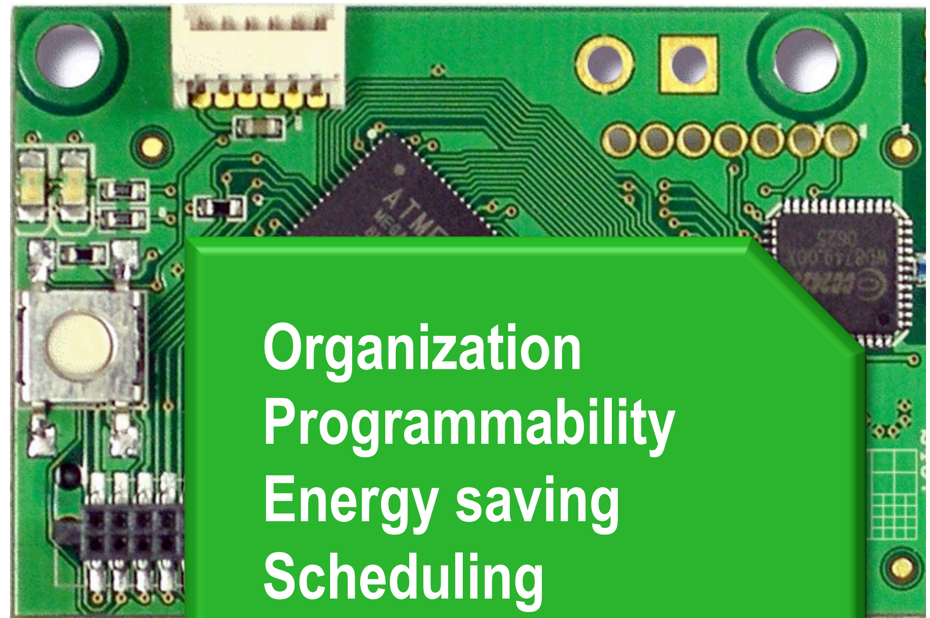
Haven't considered:

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



Are you I-o-T or WSN?

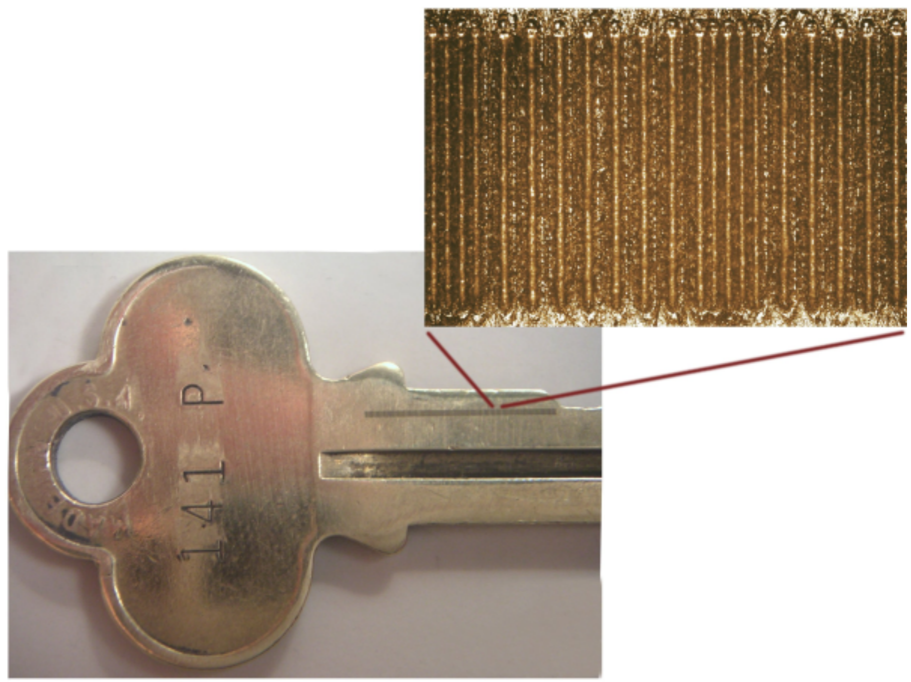
- IP integration, WWW
- IPv6
- Inter-operability
- Interactions (all kind)
- Semantic, Ontology
- Data representation
- Data logging
- WebServices, RDF, OWL, …



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

LIUPPA
T2I team
T2i

Interaction can takes many (unexpected) forms!



CONTROL, OPTIMIZE & INSTRUMENT !

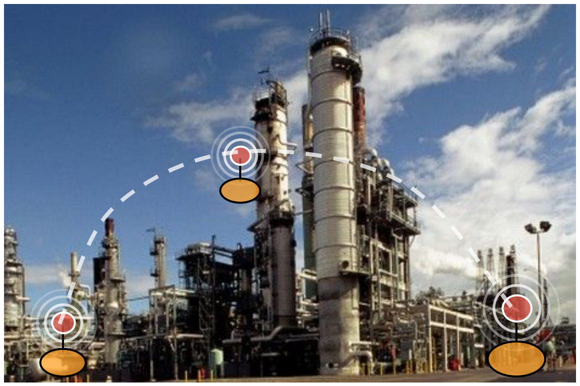
DATA ANALYSIS, OPTIMIZATION & CONTROL

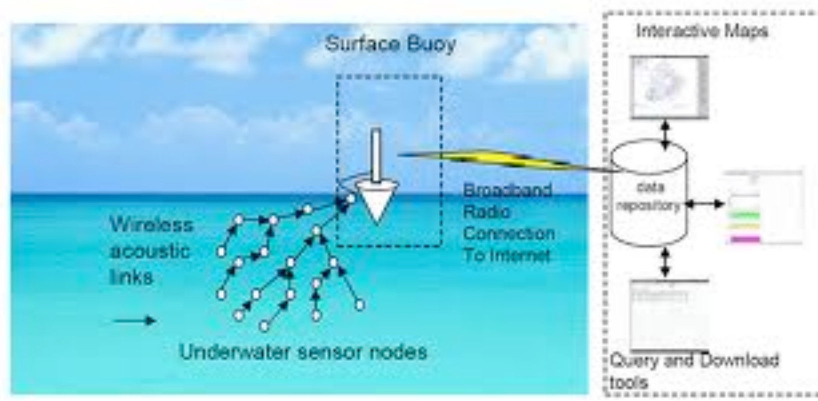
PERVASIVE SYSTEMS

SENSING

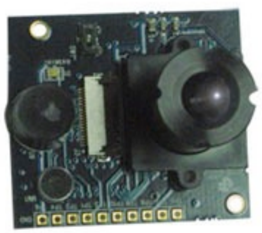
PEOPLES, INFRASTRUCTURES, BUILDINGS, VEHICULES

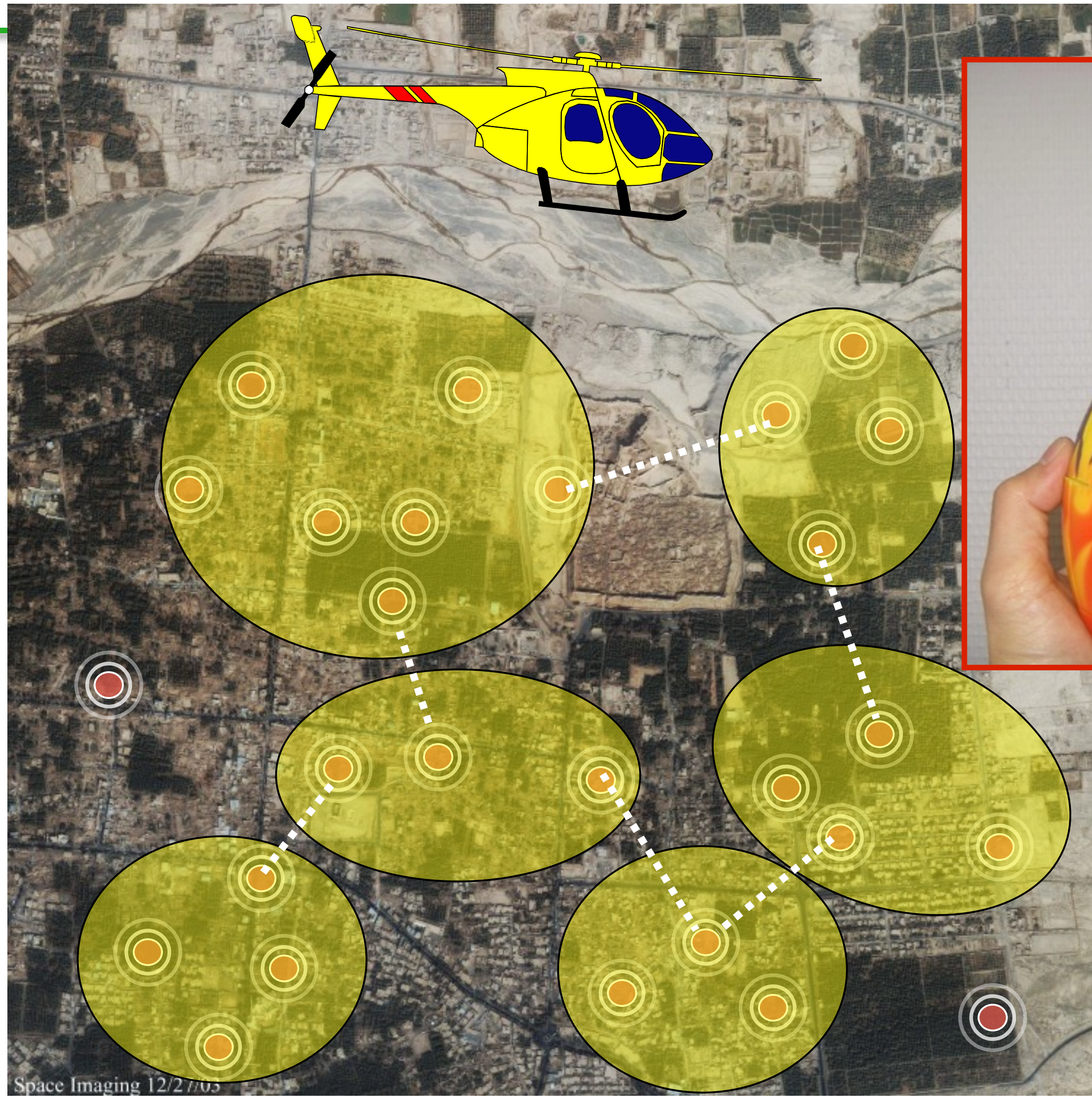
Monitoring/Surveillance

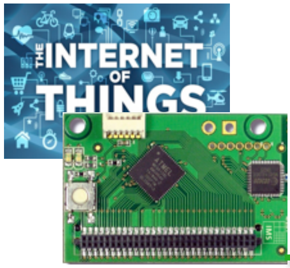




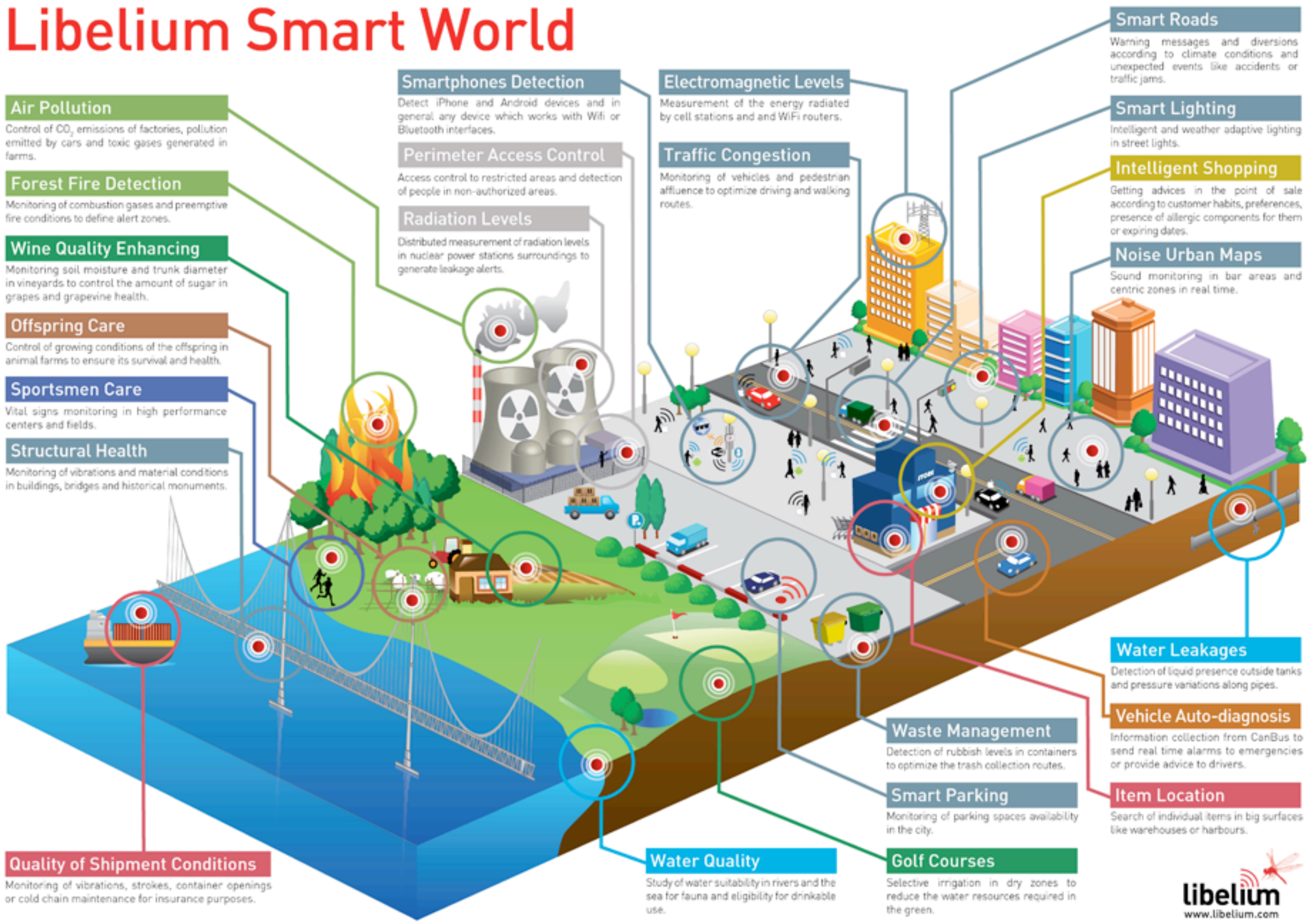
Search&Rescue, security







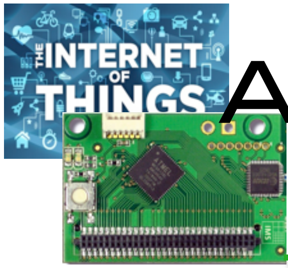
Smart Cities



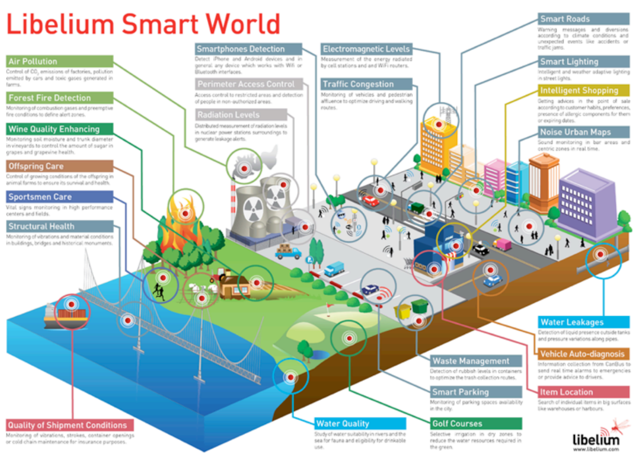
http://www.libelium.com/top_50_iot_sensor_applications_ranking/#show_infographic

SmartSantander

www.smartsantander.eu

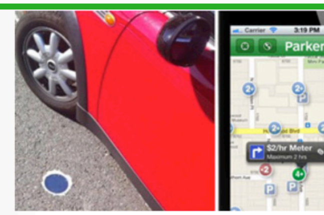


A real business model in SmartCities



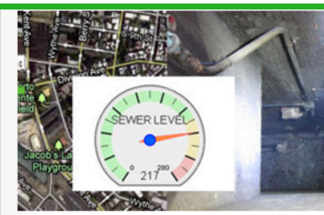
KEEP STREETS CLEAN

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

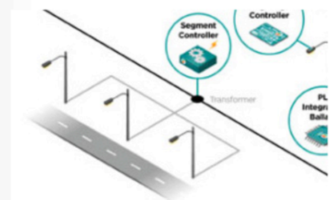


RECEIVE POLLUTION WARNINGS

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



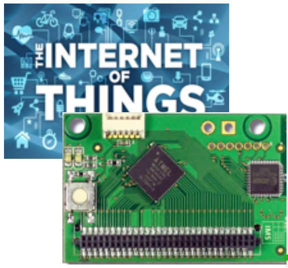
LIGHT STREETS MORE EFFECTIVELY

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

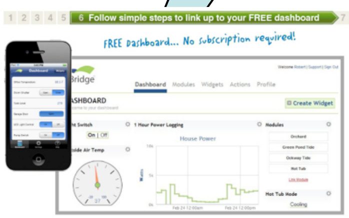
SHARE YOUR FINDINGS

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/



Control, optimize & Instrument



Pervasive Systems

Sensing

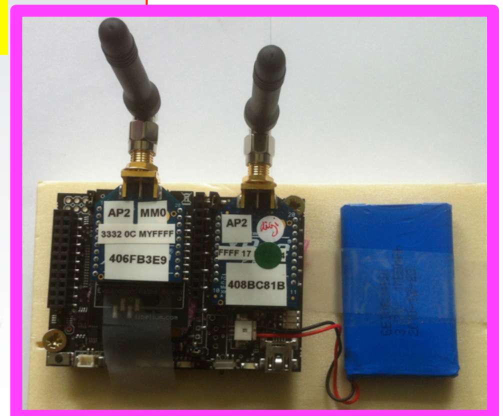
PEOPLES, INFRASTRUCTURES, BUILDINGS, VEHICULES

Mass-market sensors

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

Cost:
~100€

Libelium WaspMote



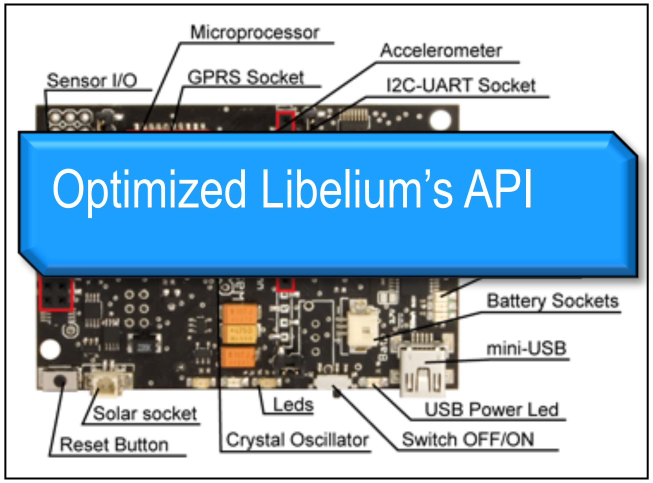
Cost:
~80€

Arduino Mega2560

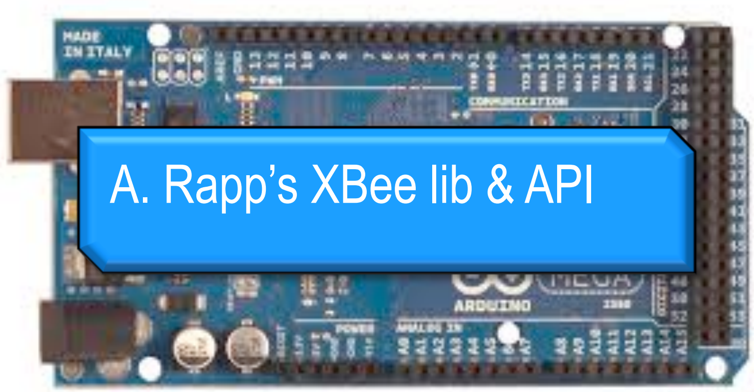
16MHz Atmega1281
8kB SRAM, 128kB Flash
Xbee radio

Sensor's HW&SW

Libelium WaspMote



Optimized Libelium's API



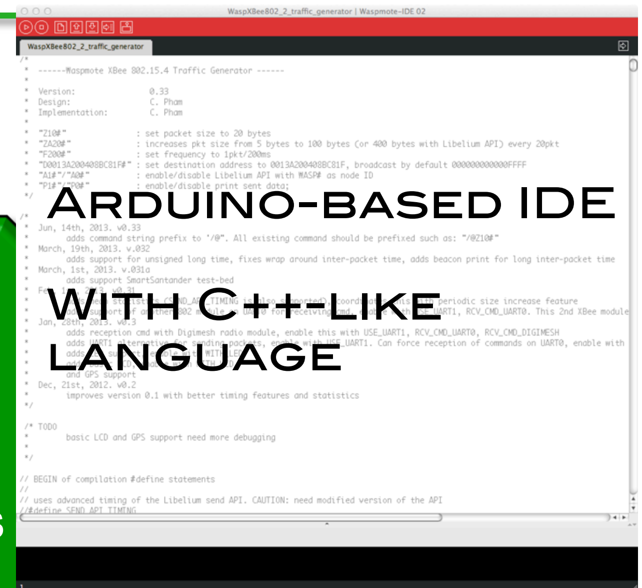
A. Rapp's XBee lib & API

Arduino Mega2560

UART-based connection to micro-controller

Default speed is usually 38400 bauds

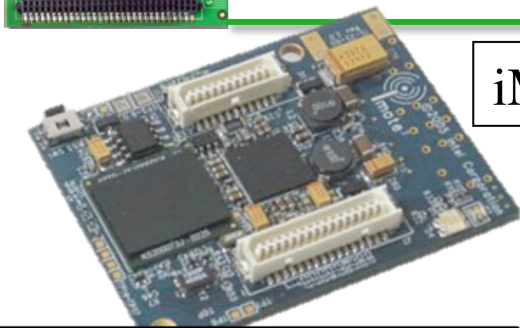
Higher baud rate are possible but…



Arduino-based IDE with C++-like language

XBee 802.15.4

« Academic » sensors



iMote2

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

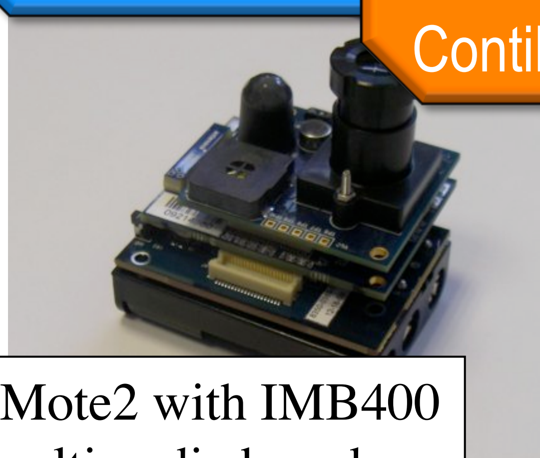
13-416MHz PXA271 Xscale
Wireless MMX DSP
256kB SRAM, 32MB
32MB SDRAM
CC2420 radio

Radio module
CC2420 is

hundredth kbps

Motes are programmed under the TinyOS operating (NesC, component-based C-like language) system & lib or Contiki (C language)

AdvanticSys CM5000 & CM3000
TelosB-like mote

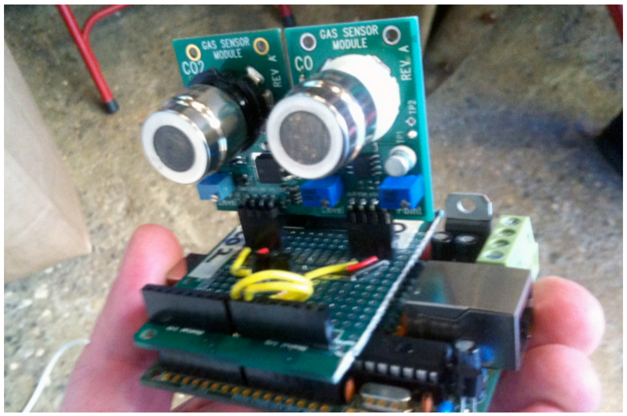


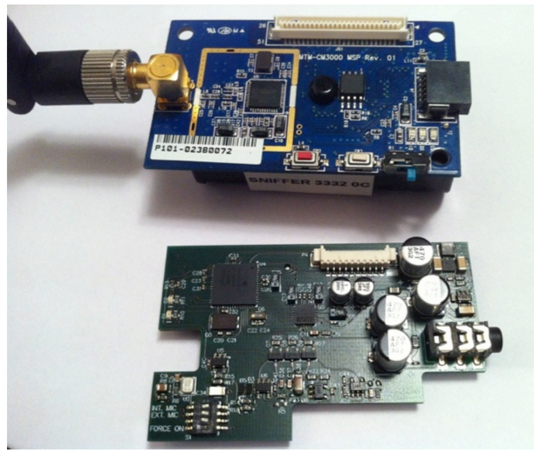
iMote2 with IMB400
multimedia board

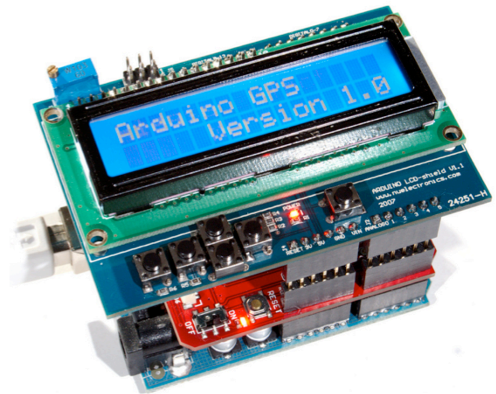
TelosB

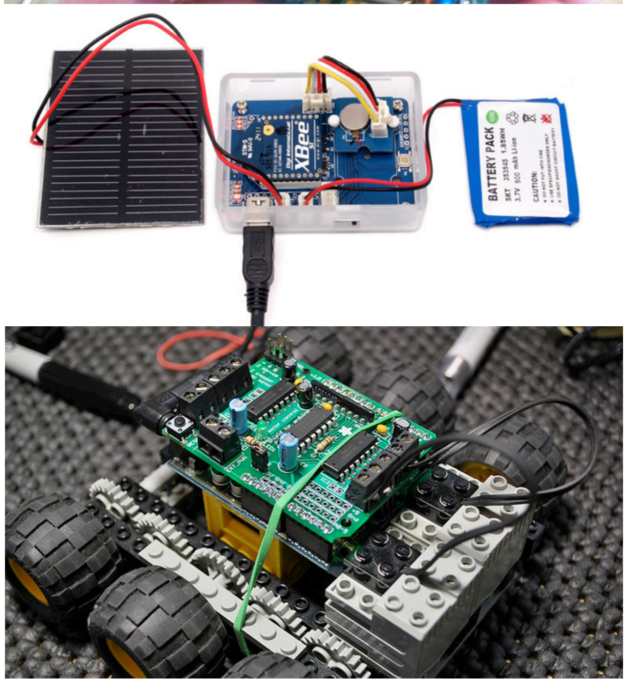
8Mhz MSP430F1611
10K SRAM, 48K flash
CC2420 radio

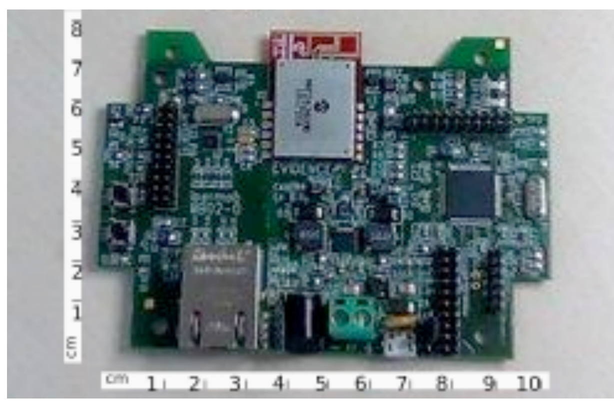
From custom developments...



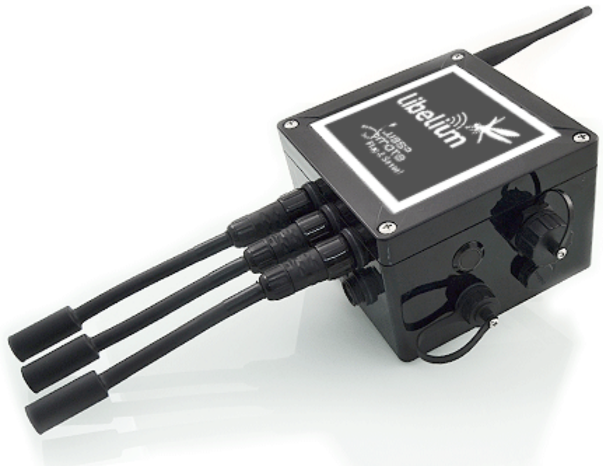


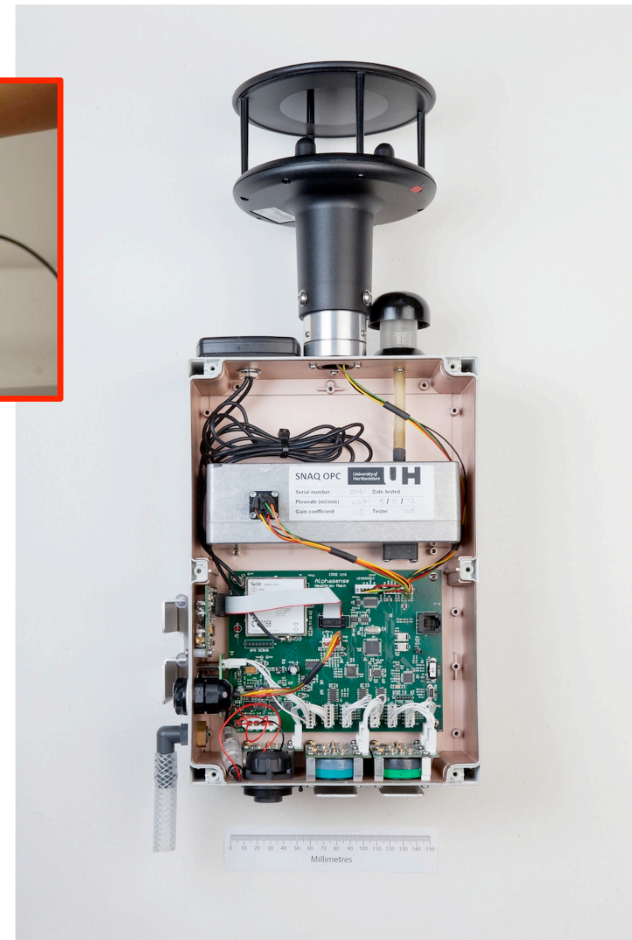




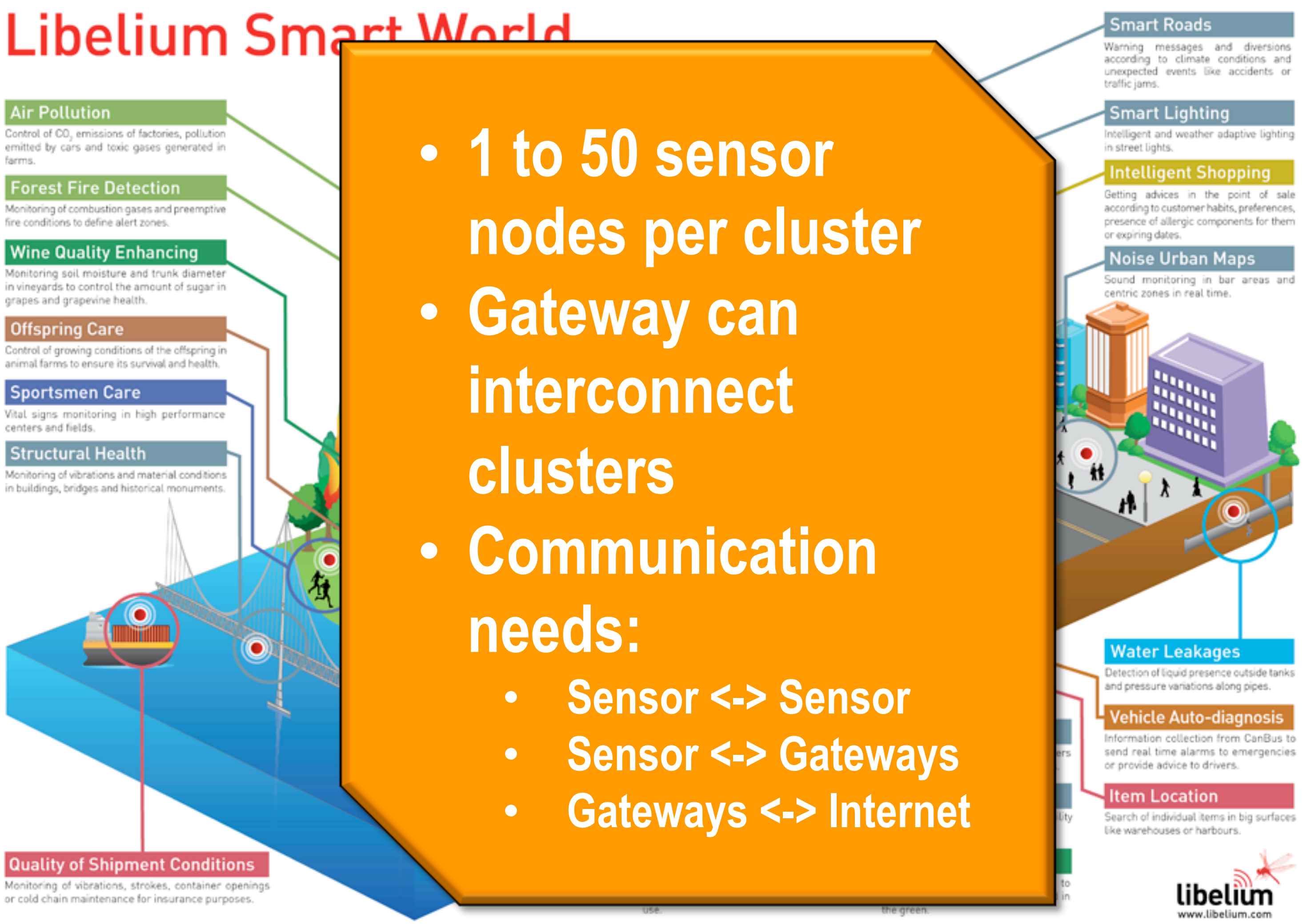


...TO COMMERCIAL PRODUCTS



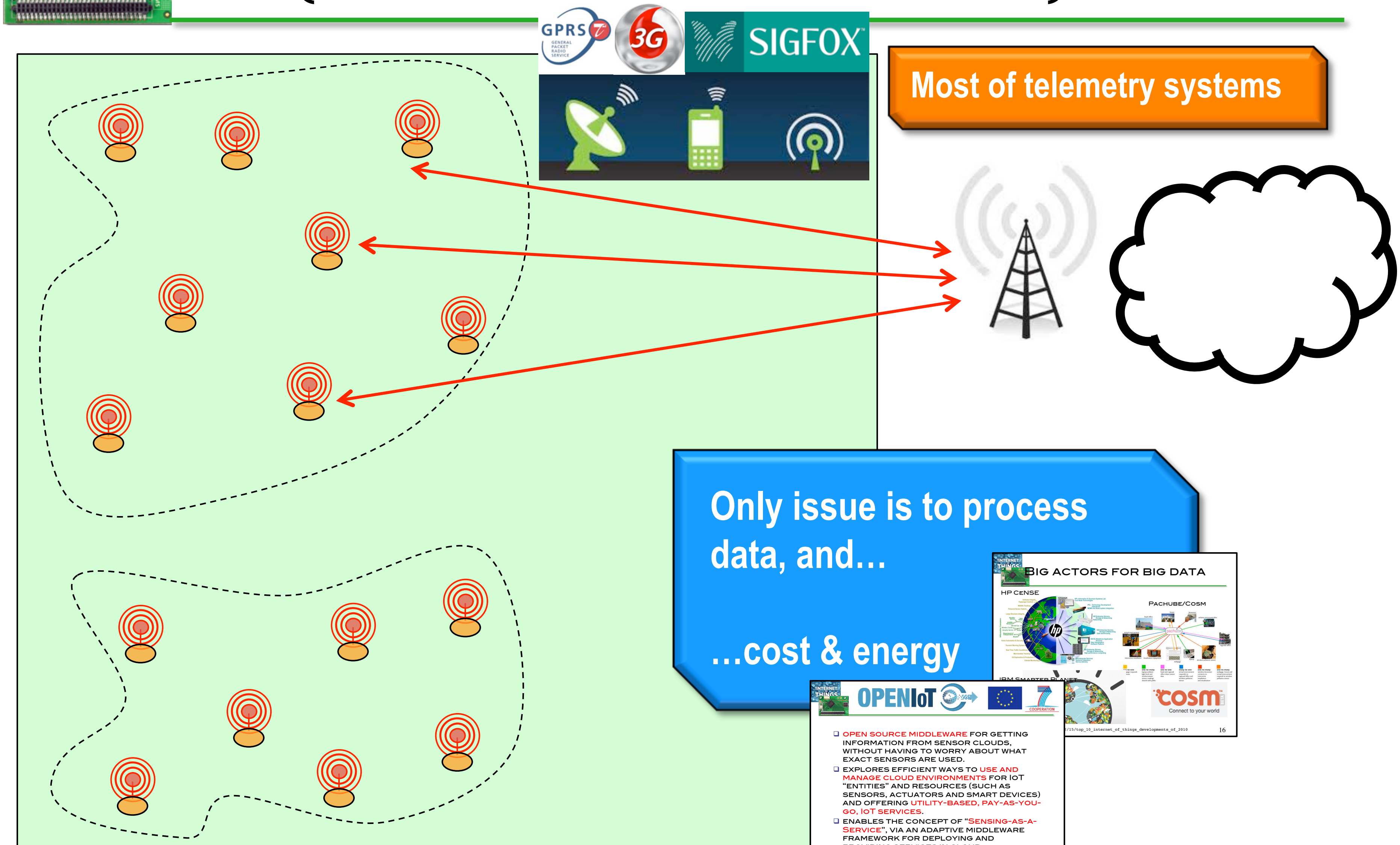


Deployment in Practice



- 1 to 50 sensor nodes per cluster
- Gateway can interconnect clusters
- Communication needs:
  - Sensor <-> Sensor
  - Sensor <-> Gateways
  - Gateways <-> Internet

1-HOP COMMUNICATION (CELLULAR MODEL)



Big actors for big data

HP CeNSE

Pachube/Cosm

IBM Smarter Planet

cosm
Connect to your world

2/15/top_10_internet_of_things_developments_of_2010

16

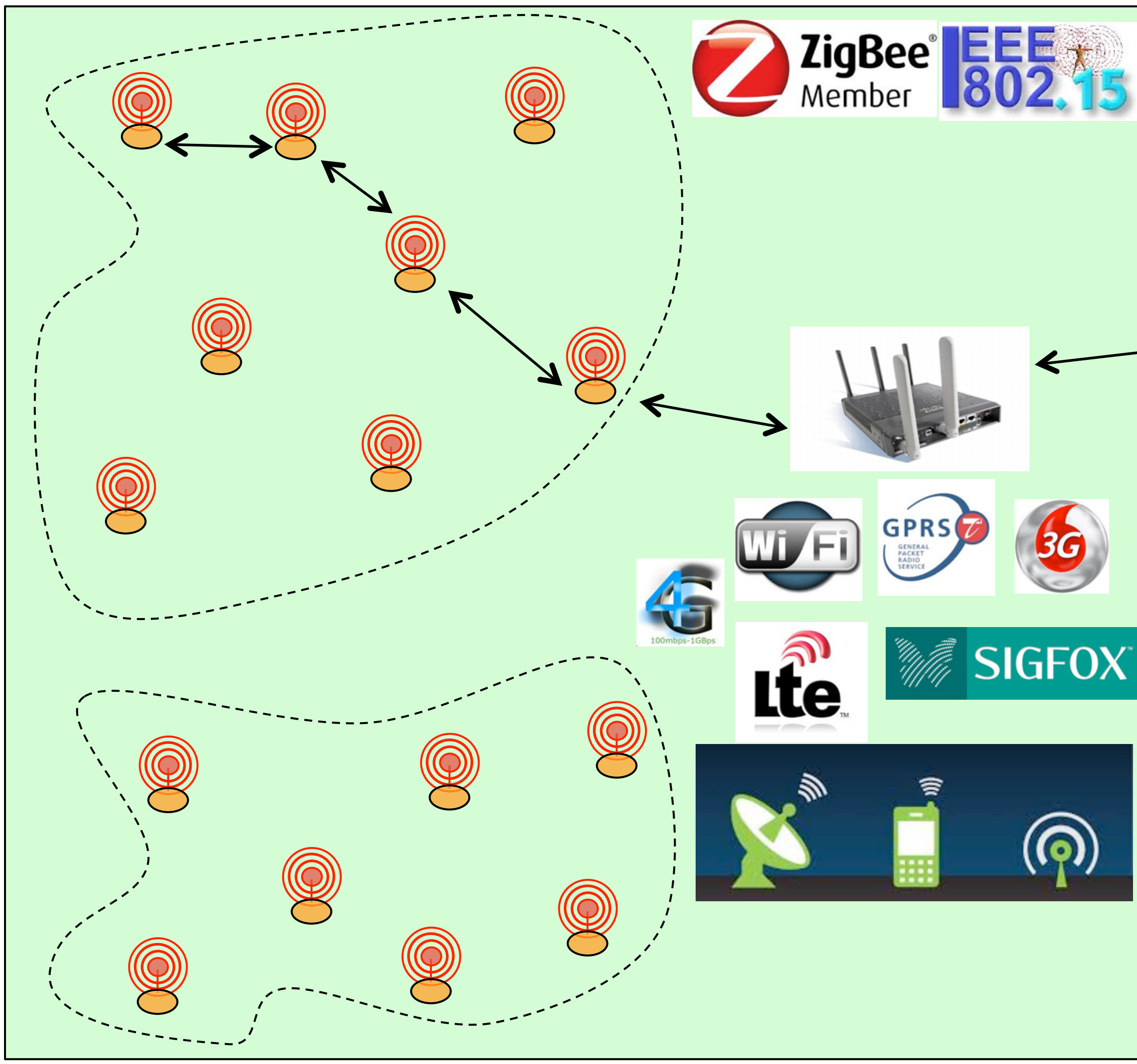
OPENIoT

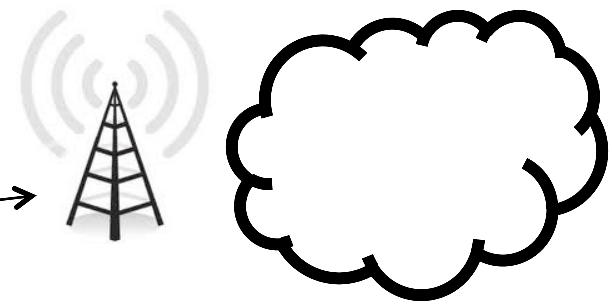
COOPERATION

- OPEN SOURCE MIDDLEWARE FOR GETTING INFORMATION FROM SENSOR CLOUDS, WITHOUT HAVING TO WORRY ABOUT WHAT EXACT SENSORS ARE USED.
- EXPLORES EFFICIENT WAYS TO USE AND MANAGE CLOUD ENVIRONMENTS FOR IoT "ENTITIES" AND RESOURCES (SUCH AS SENSORS, ACTUATORS AND SMART DEVICES) AND OFFERING UTILITY-BASED, PAY-AS-YOU-GO, IoT SERVICES.
- ENABLES THE CONCEPT OF "SENSING-AS-A-SERVICE", VIA AN ADAPTIVE MIDDLEWARE FRAMEWORK FOR DEPLOYING AND PROVIDING SERVICES IN CLOUD ENVIRONMENTS

20

Multi-hop to gateways



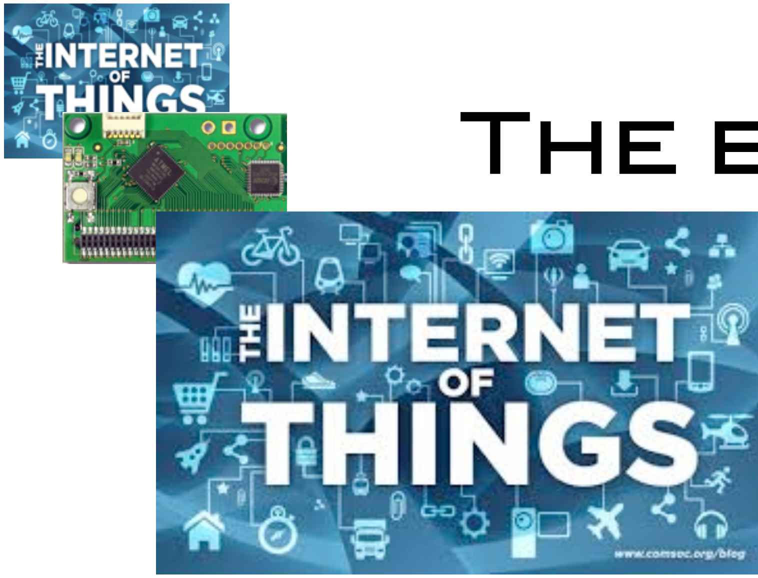


MAC & Routing issues, well-known to WSN community…

…but can we interoperate?

From ad-hoc to standardized protocols

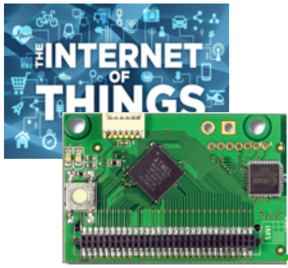
The benefit of IP



Don't reinvent the wheel!

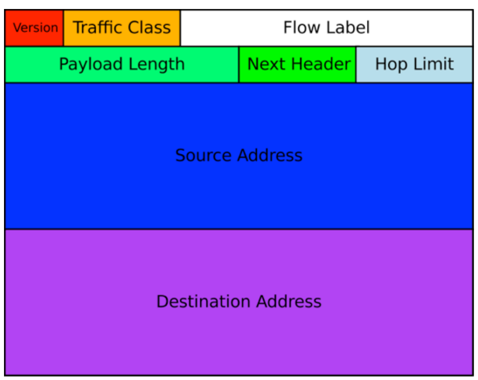
RFC 768	UDP - User Datagram Protocol	[1980]
RFC 791	IPv4 – Internet Protocol	[1981]
RFC 792	ICMPv4 – Internet Control Message Protocol	[1981]
RFC 793	TCP – Transmission Control Protocol	[1981]
RFC 862	Echo Protocol	[1983]
RFC 1101	DNS Encoding of Network Names and Other Types	[1989]
RFC 1191	IPv4 Path 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"

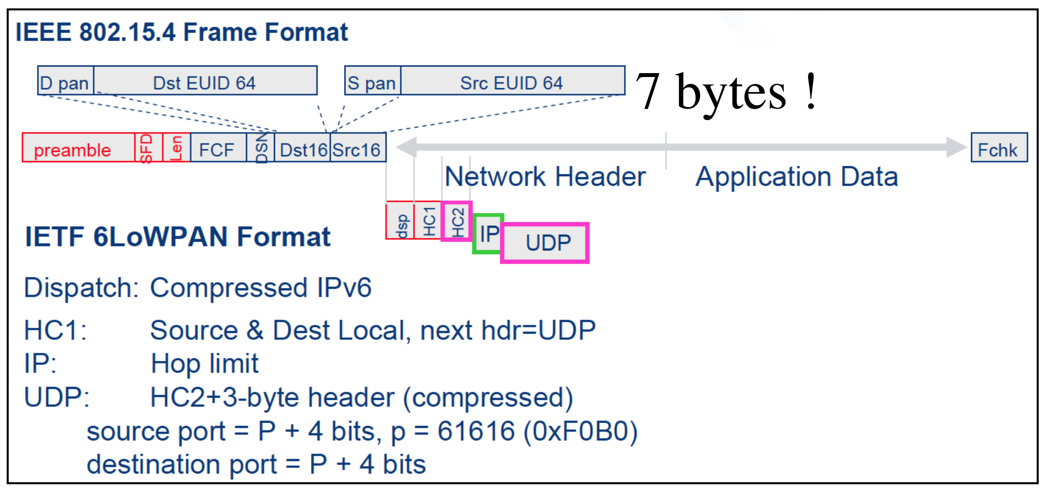


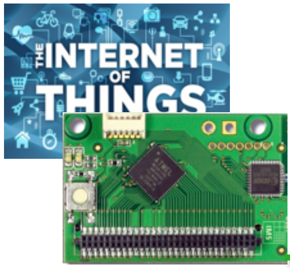
IP need IP addresses!

- 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





Internet for things

CoAP: Constrained Application Protocol

UDP

RPL
Routing Protocol for Low power & Lossy Networks

6LowPan
802.15.4

HTTP

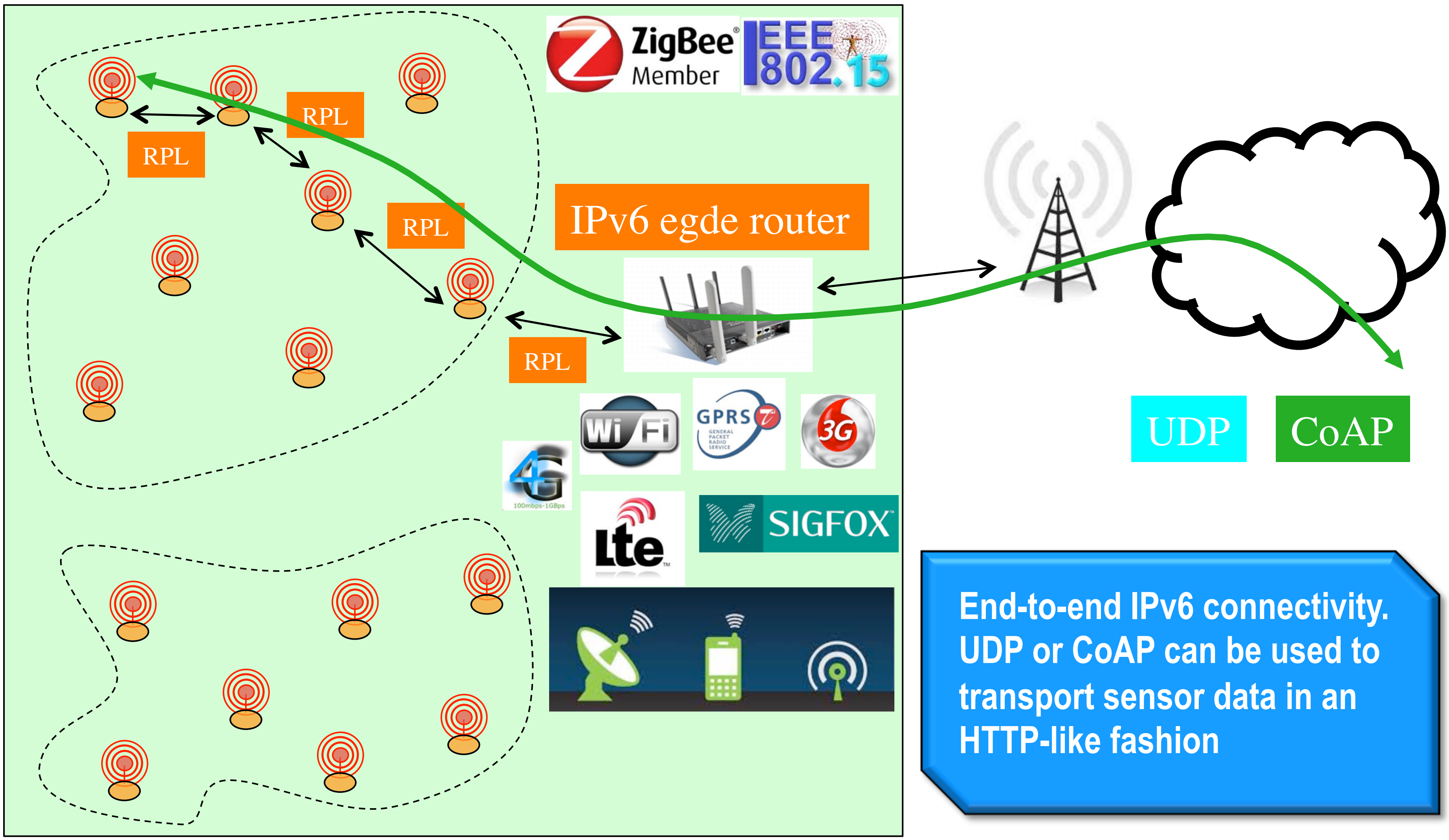
TCP, UDP

Internet Routing Protocols: RIP, OSPF, BGP,…

IPv4, IPv6

3G 4G Lte Wi Fi

Using IP protocols



Digital Wireless World