IoT FOR SURVEILLANCE APPLICATIONS

(AND HOW TO CONNECT & SCHEDULE THEM)

EU-SEA WORKSHOP AND COOPERATION
ON IoT AND OPEN PLATFORMS

JANUARY 25TH, 2015

IEEE RIVF 2015, CAN THO, VIETNAM

PROF. CONGDUC PHAM
HTTP://WWW.UNIV-PAU.FR/~CPHAM
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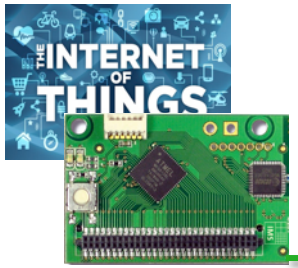
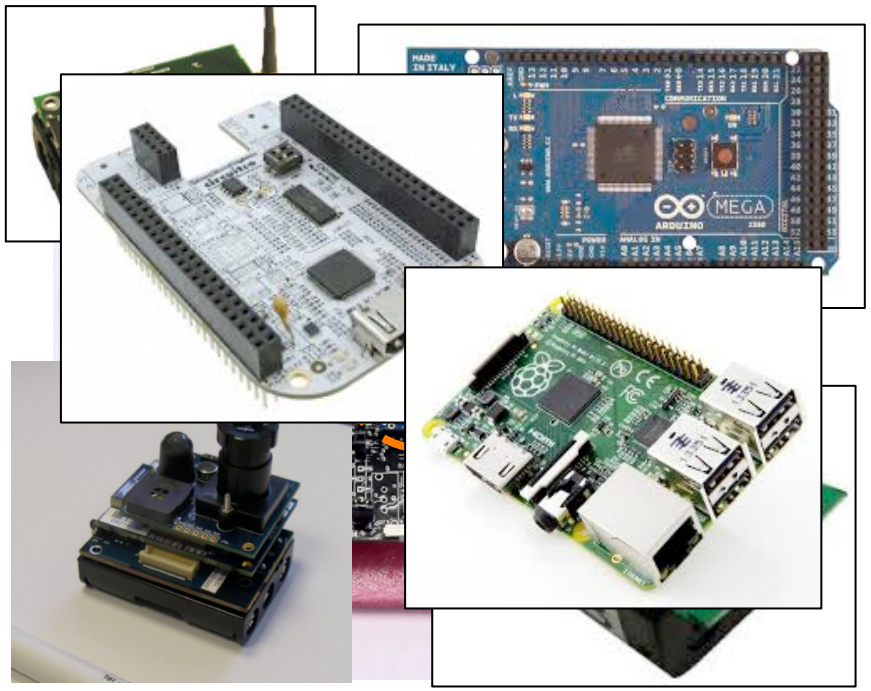
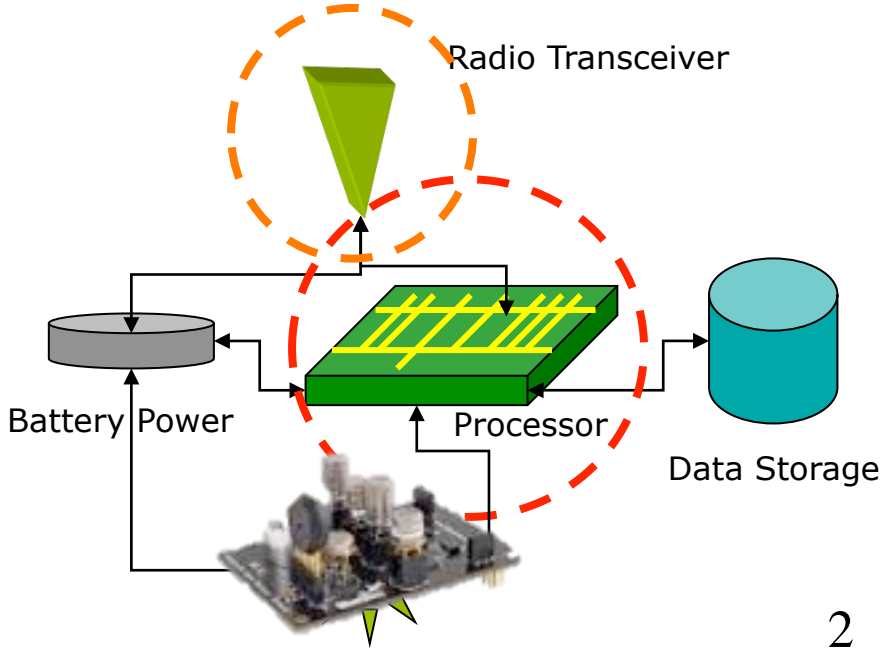


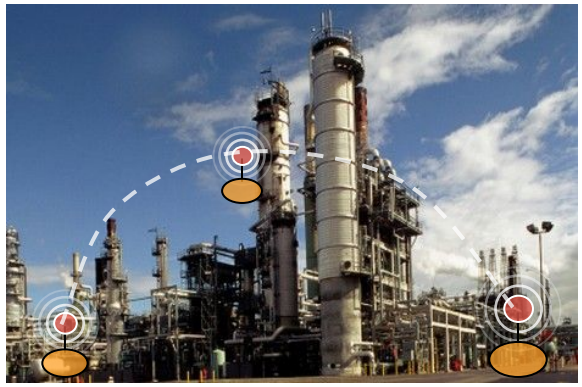
Before IoT: wireless autonomous sensor

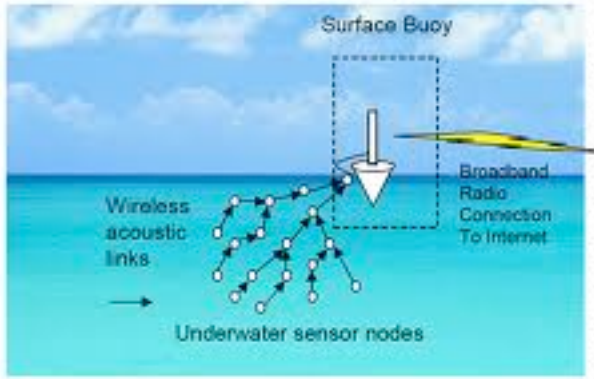
- In general: low cost, low power (the battery may not be replaceable), small size, possibly disposable
- Sense the environment for physical properties: temperature, presence,...
- Still the main dev. Platform for IoT

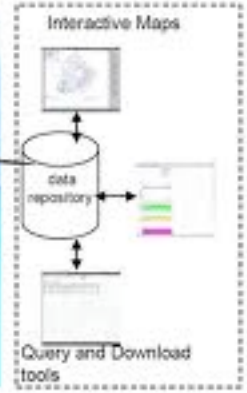


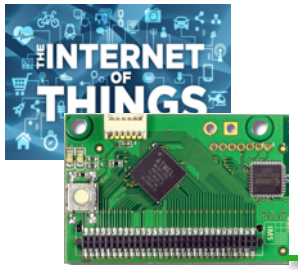


« Naturally » well suited for Monitoring/Surveillance









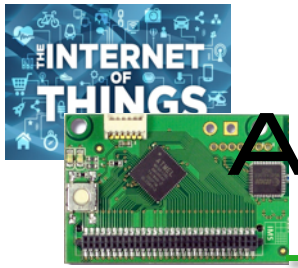
Collect data & instrument !

DATA ANALYSIS, OPTIMIZATION & CONTROL

PERVASIVE SYSTEMS

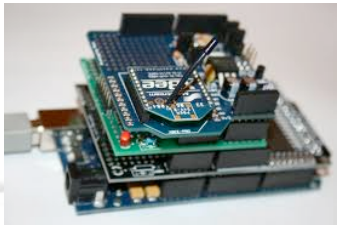
SENSING

PEOPLES, INFRASTRUCTURES, BUILDINGS, VEHICULES

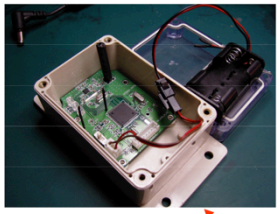


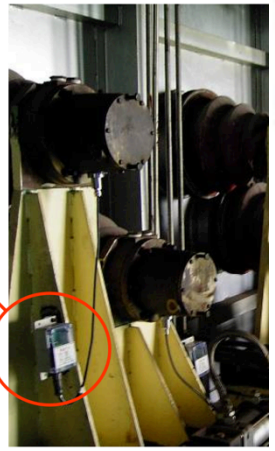
Academics vs Industries

Millions of sensors, self-organizing, self-configuring, with QoS-based multi-path routing, mobility, and …



50 sensors, STATIC deployment, but need to have RELIABILITY, GUARANTEED LATENCY for monitoring and alerting. MUST run for 3 YEARS. No fancy stuff! CAN I HAVE IT?

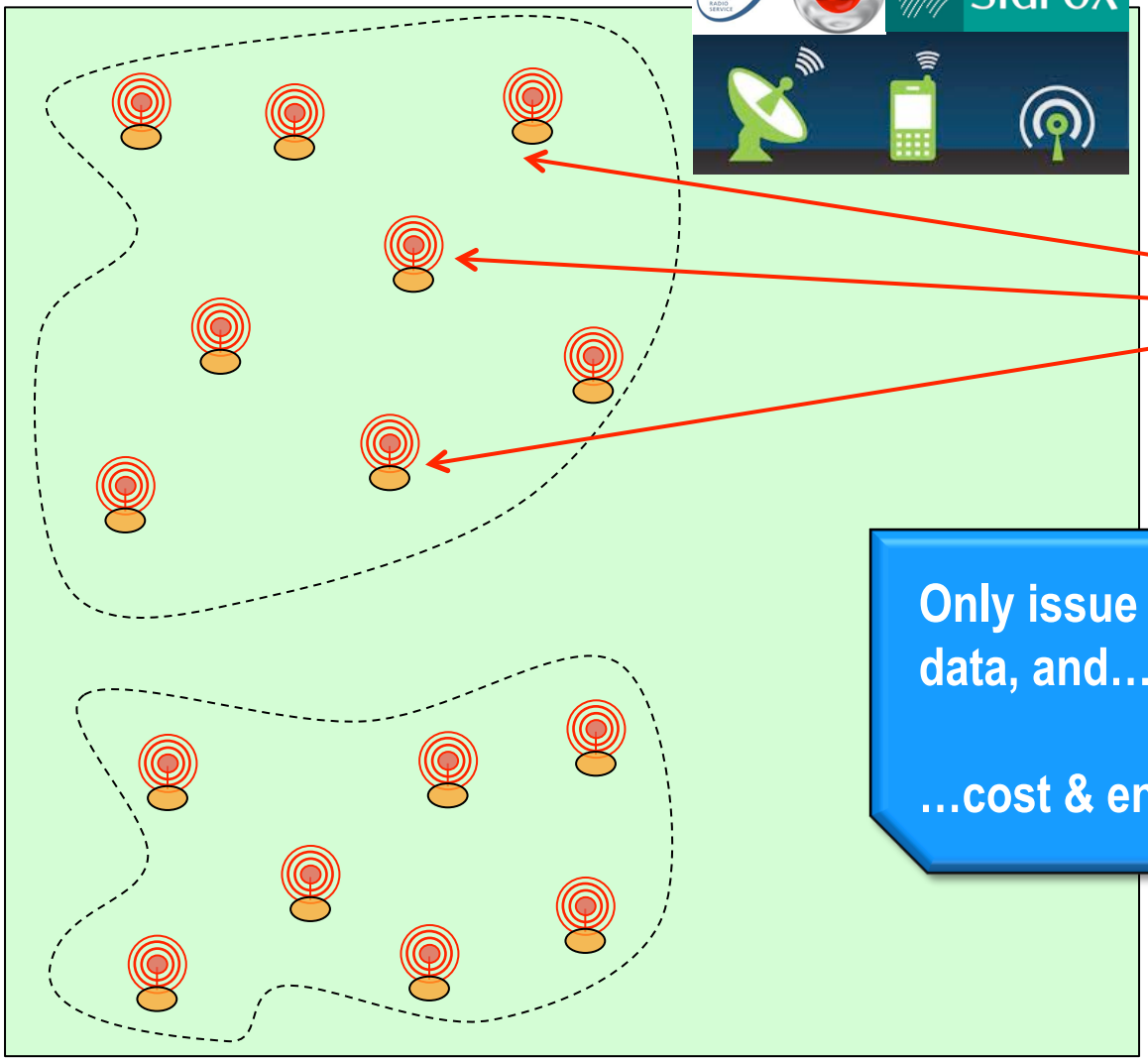




- Placement constraints
- Lifetime constraints

From Peng Zeng & Qin Wang

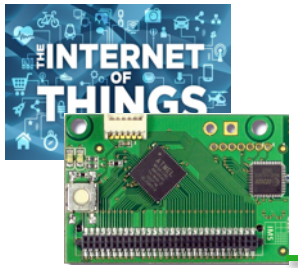
1-HOP COMMUNICATION



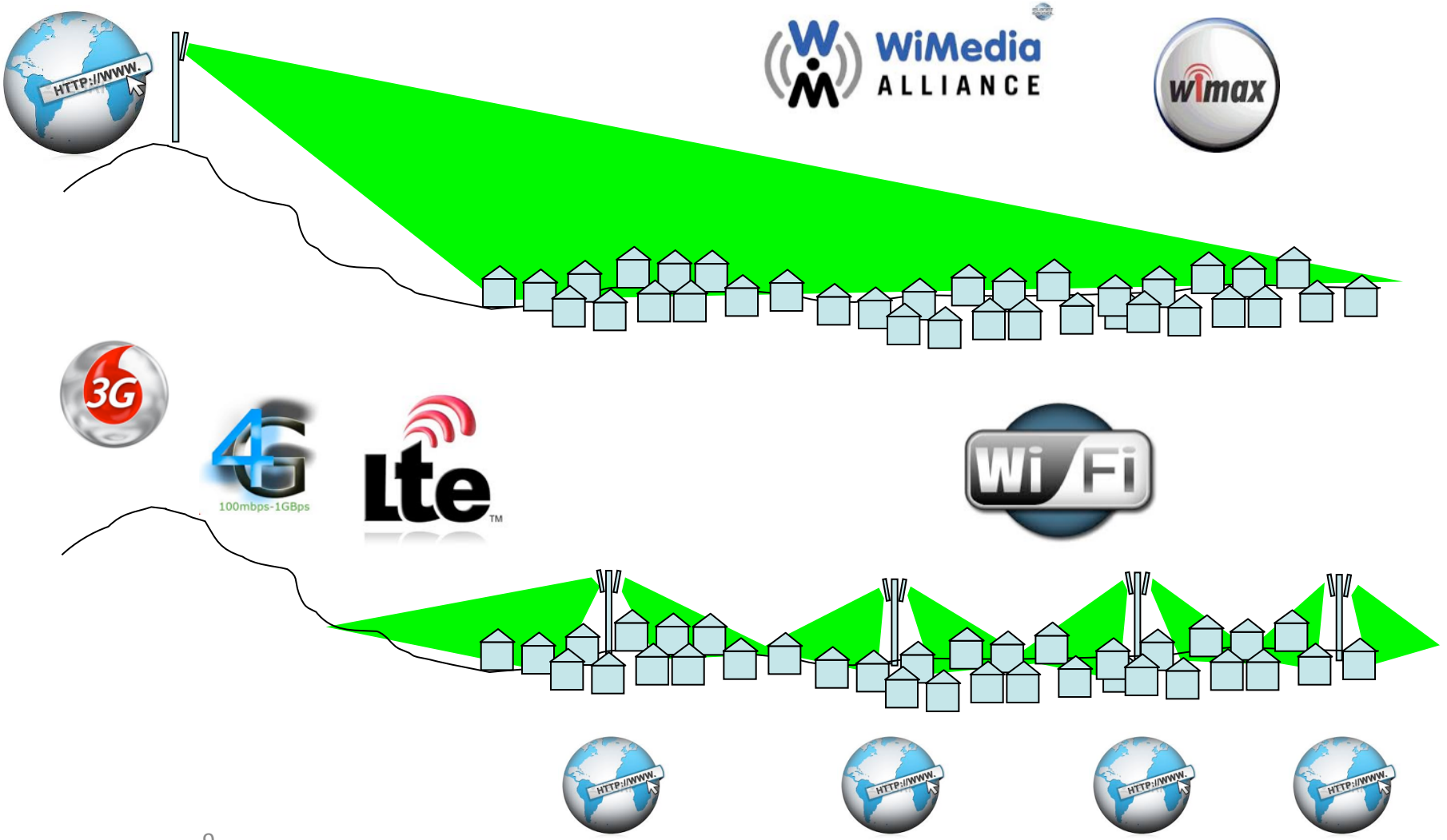
Most of telemetry systems

Only issue is to process data, and…

…cost & energy

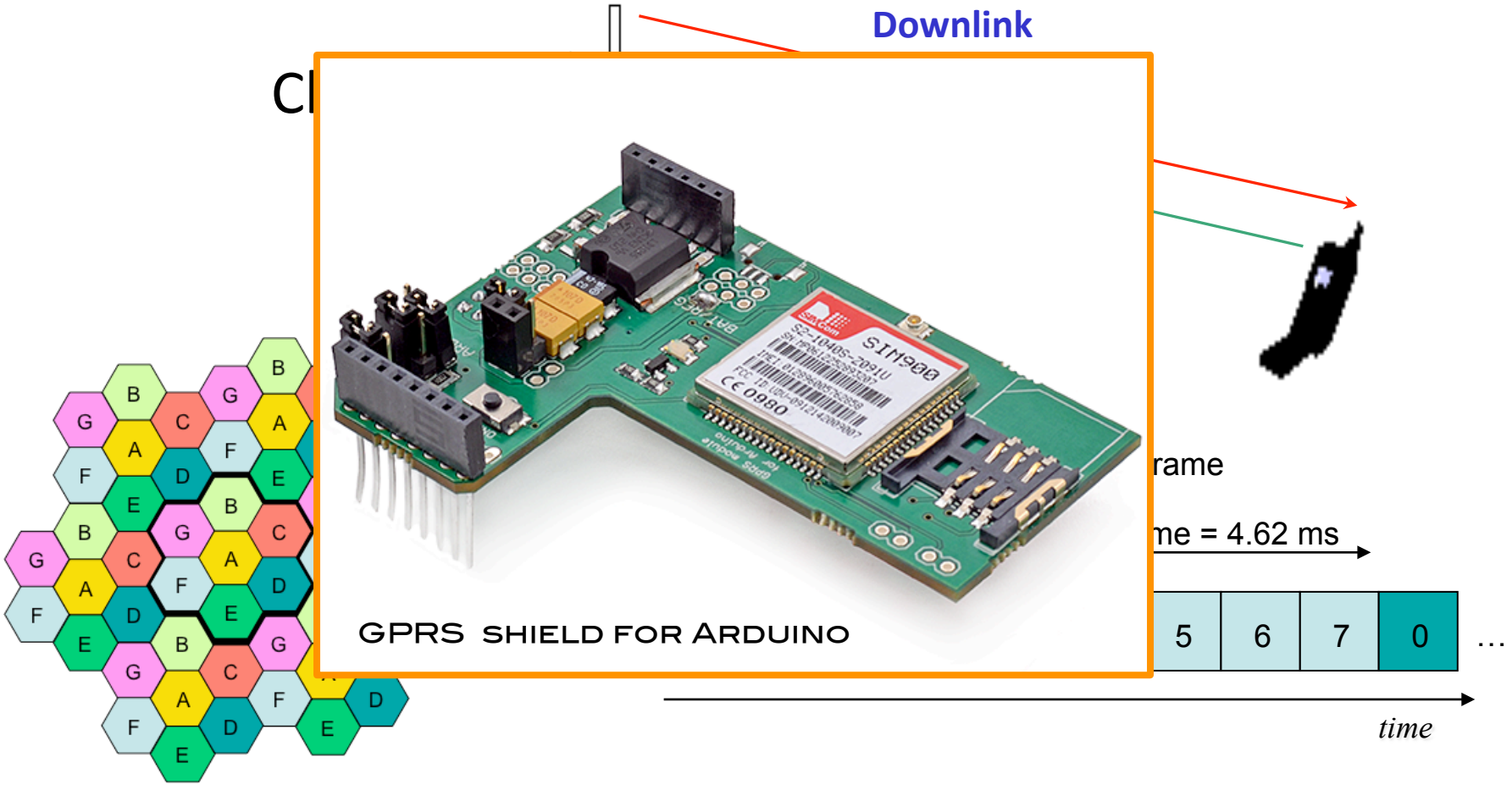


Cellular model



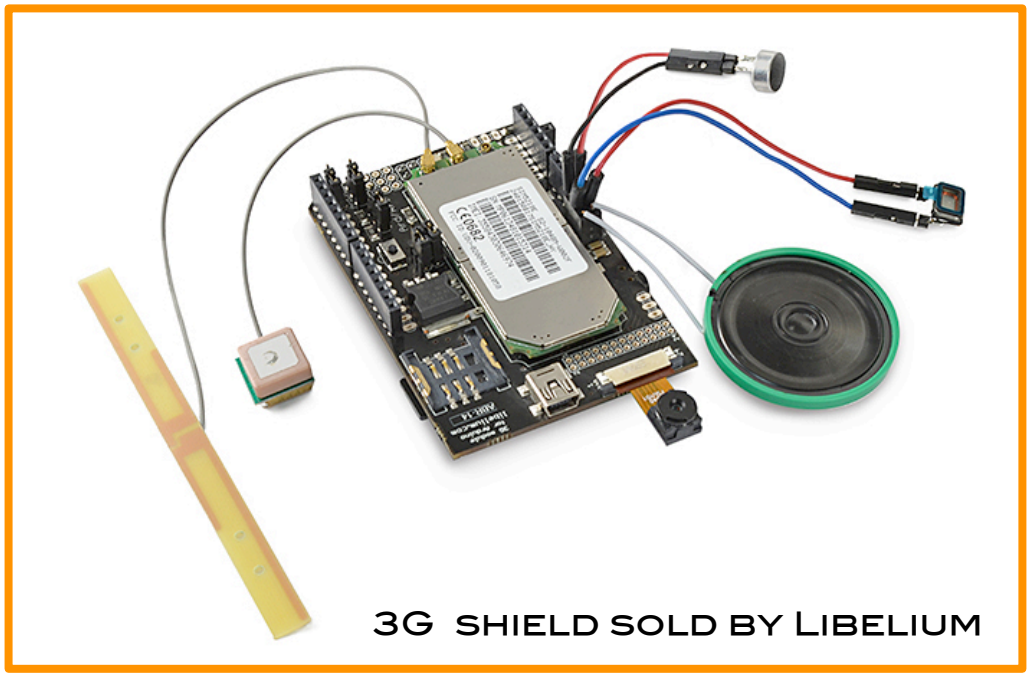
9

GSM (2G)/GPRS



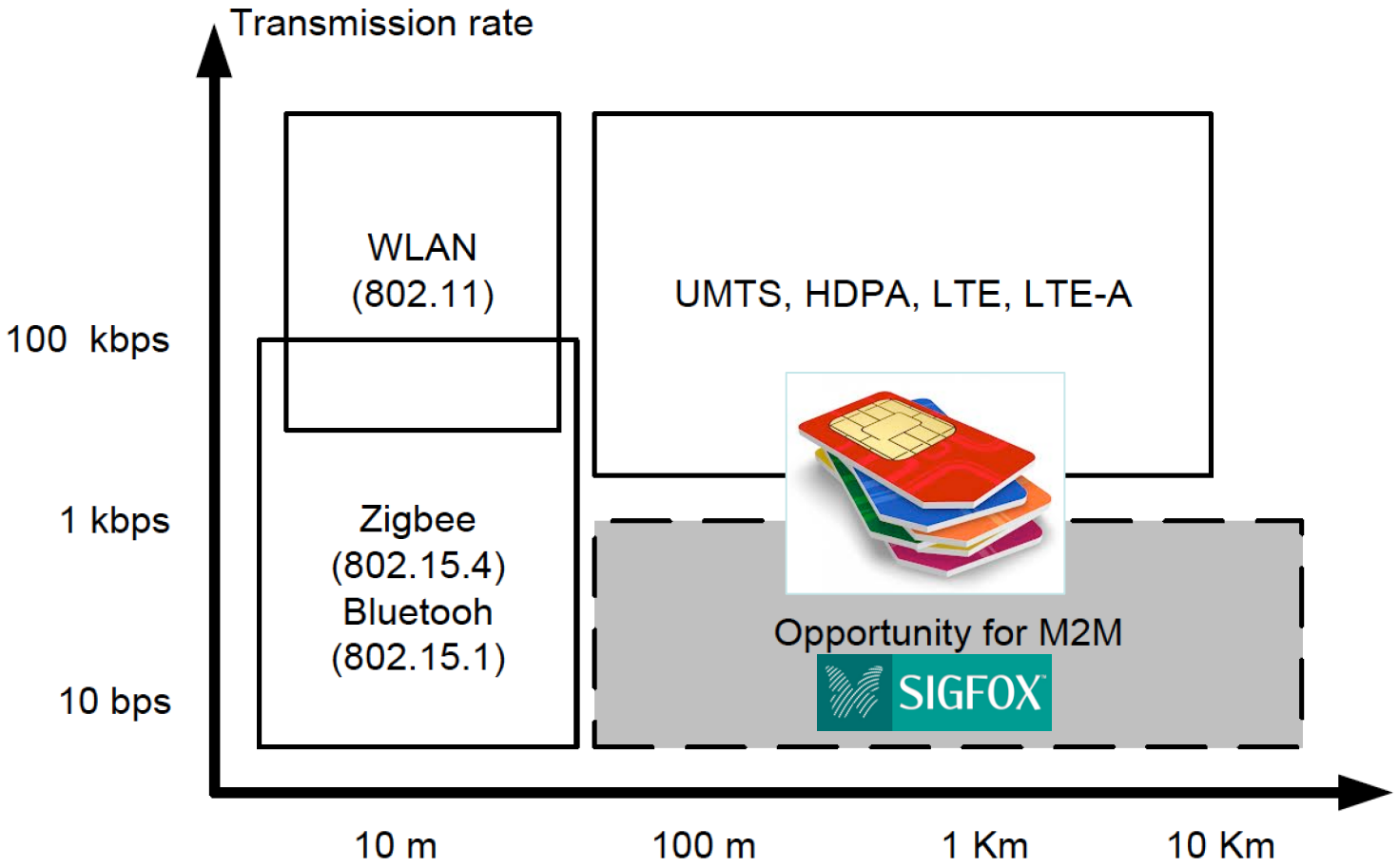
3G AND BEYOND

- 3G AND BEYOND USE CDMA TECHNIQUES



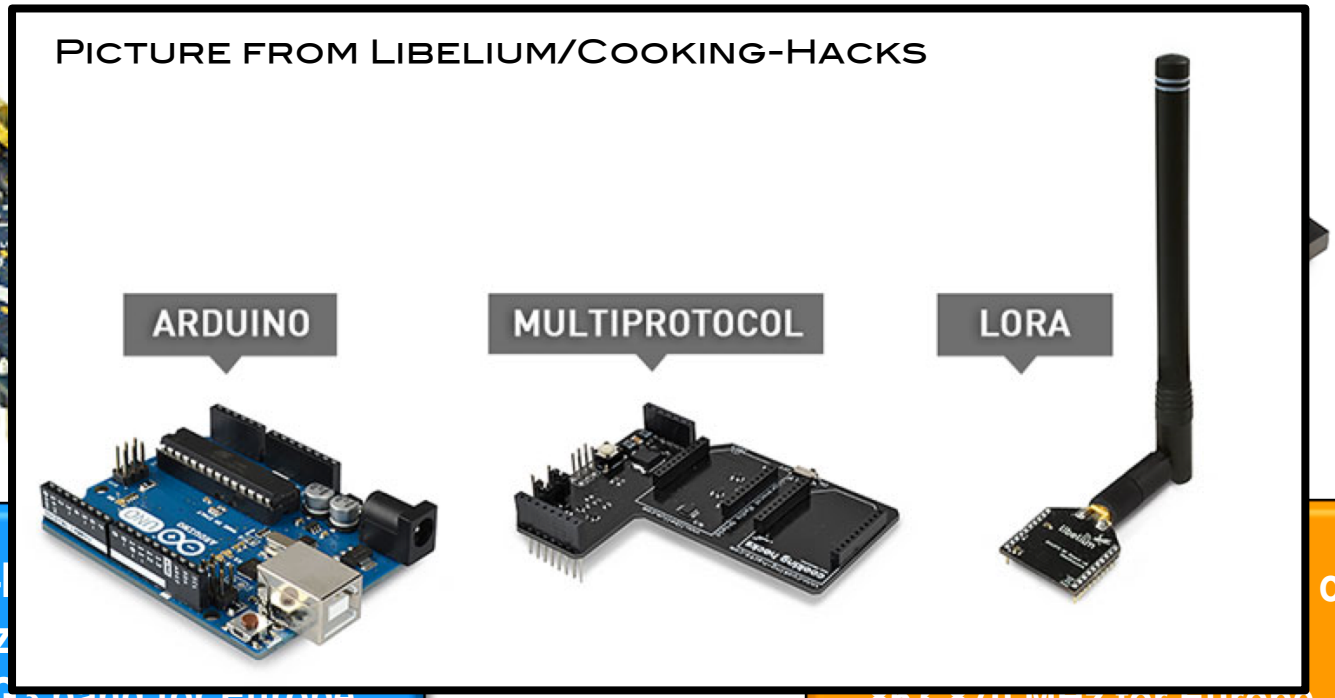
3G SHIELD SOLD BY LIBELIUM

Opportunities for Telco operators & more...



Enhanced from M. Dohler "M2M in SmartCities"

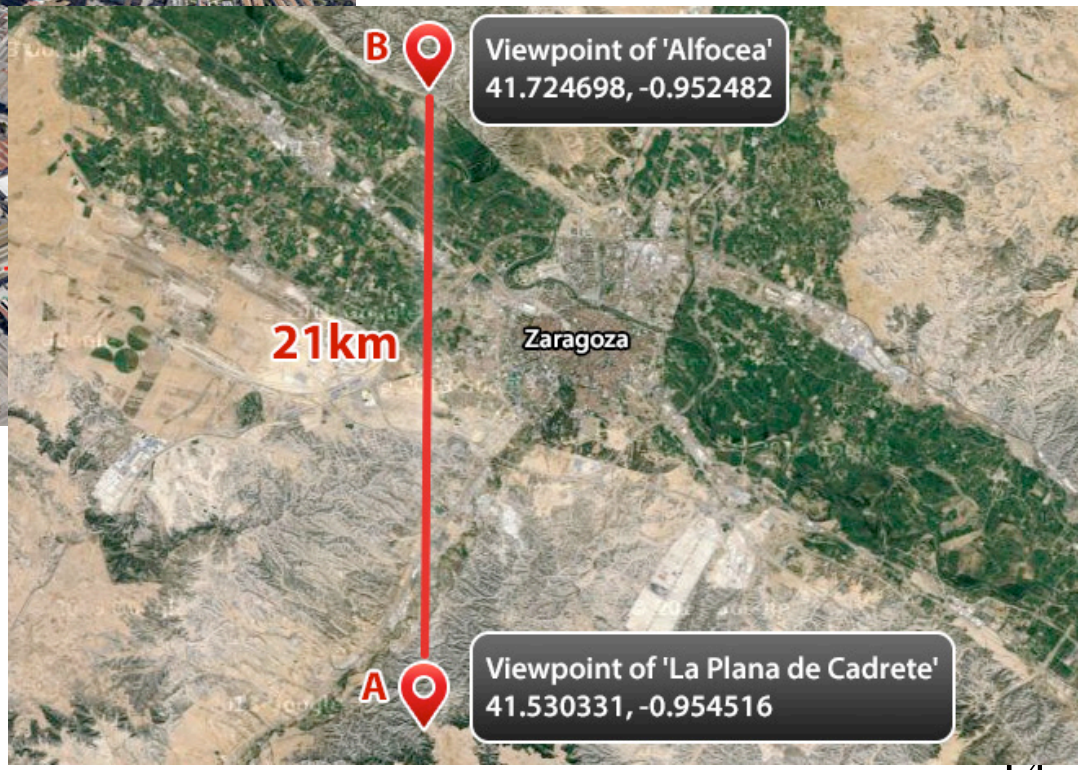
Private long distance communications



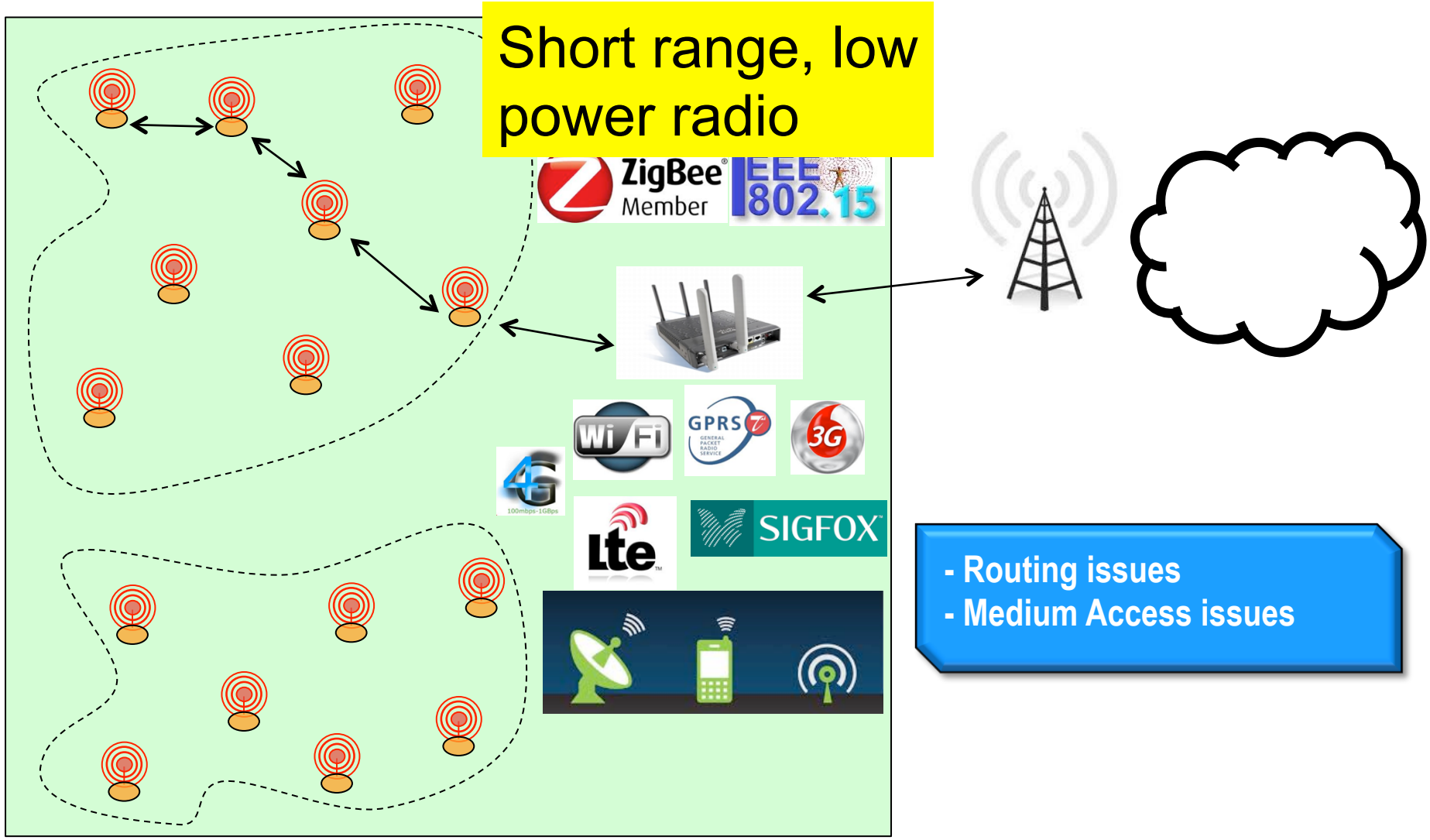
XBEE—
868 MHz
device G3 band for Europe
Outdoor RF line-of-sight
range up to 40 km
Data rate of 24 Kbps

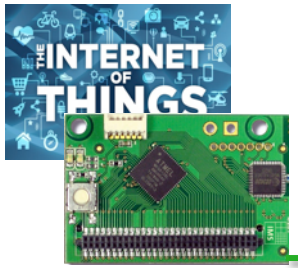
on
863-870 MHz for Europe
Outdoor RF line-of-sight
range up to 22 km in LOS
and 2km in NLOS
Data rate?

Tests from Libelium



Multi-hop to gateways





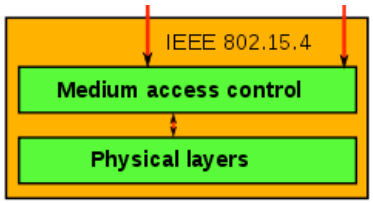
IEEE 802.15.4

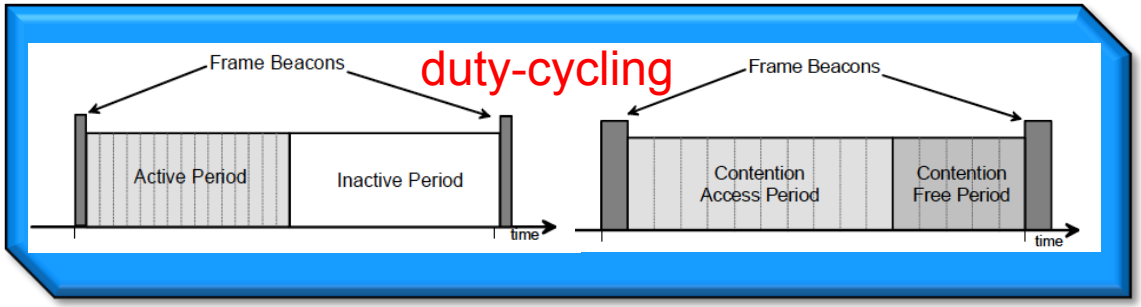
ZigBee Member

WirelessHART

ISA 100 WIRELESS

OSI 3 & 4

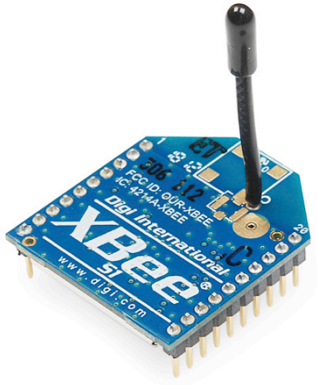




OSI 2

OSI 1

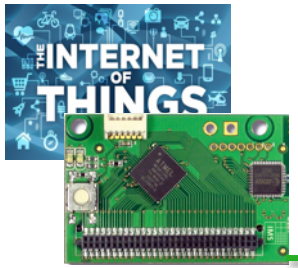
CC2420 (TI)



XBee (Digi)

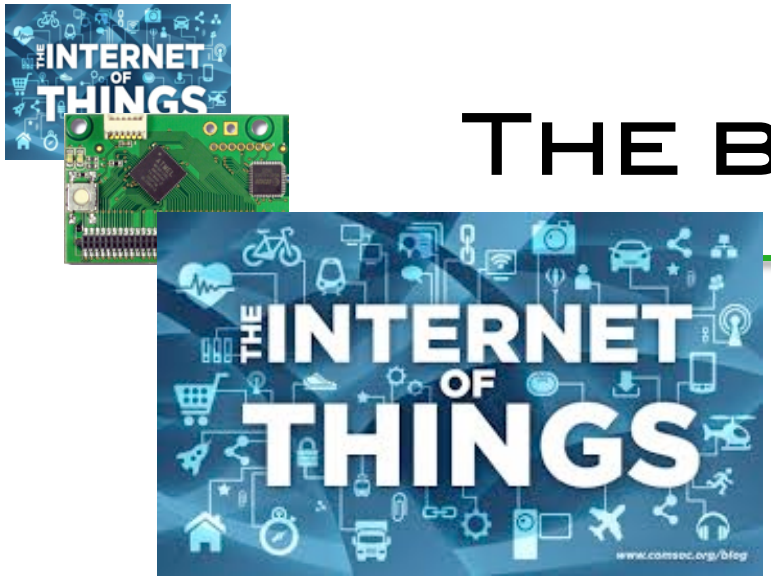
MRF24J40MA (Microchip)

ZigBit AT86RF230 (ATMEL)



Maturation of the market: WSN→IoT

The benefit of IP



IPv6

IPv6

IPv6

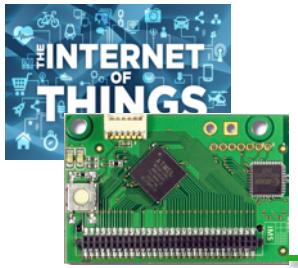
IPv6

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]

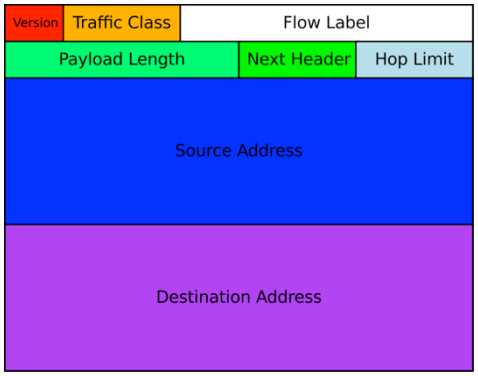
RFC6282 Compression Format for IPv6 Datagrams over IEEE 802.15.4-Based Networks [2011]

From ArchRock "6LowPan tutorial"

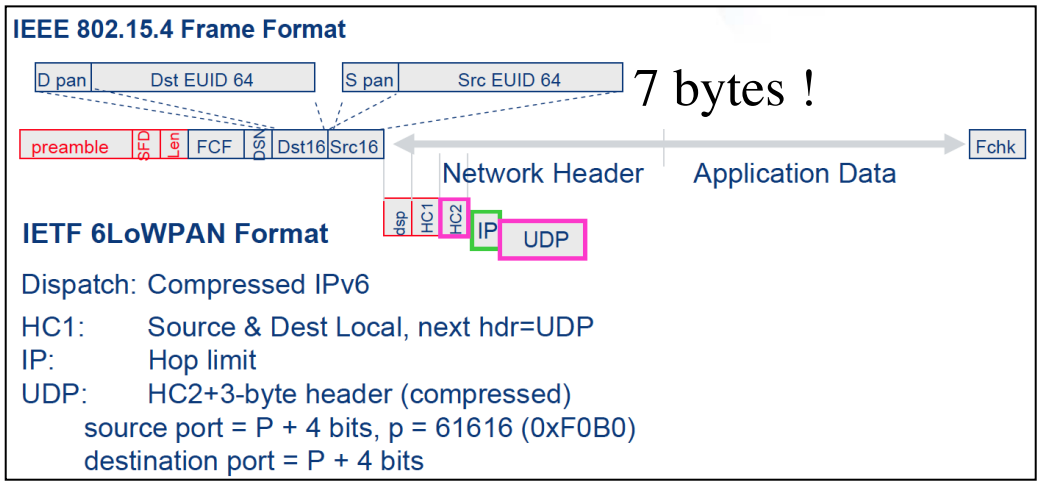


IP need IP addresses!

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

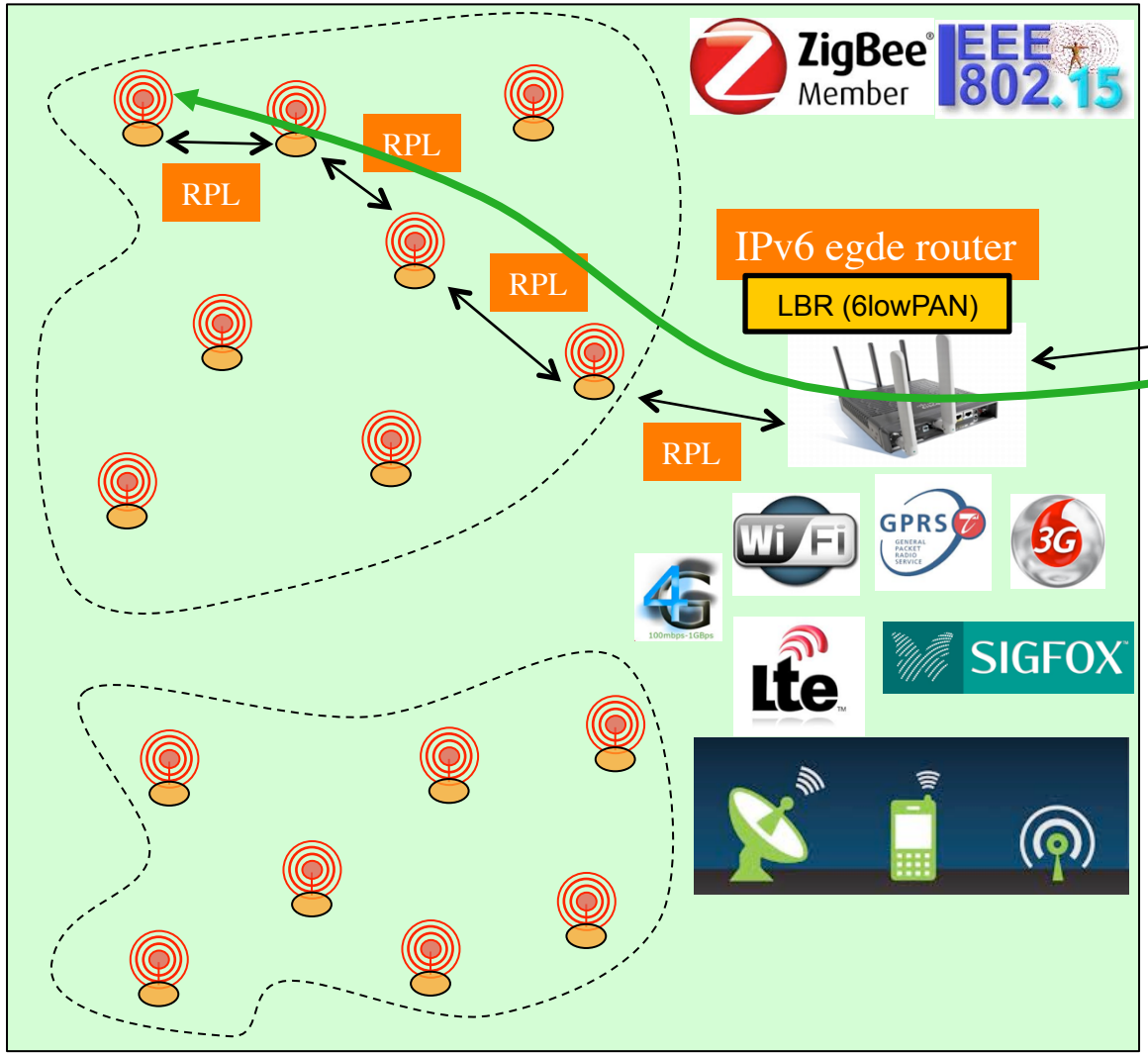


40 bytes



From ArchRock "6LowPan tutorial"

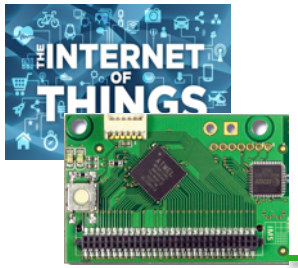
Routing over Low Power & Lossy Networks (RPL)



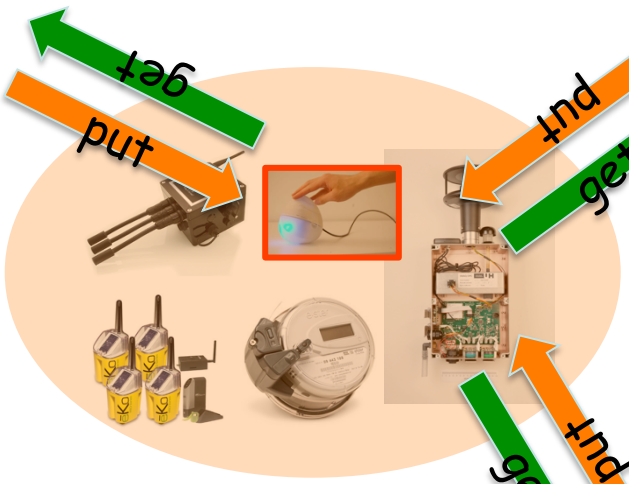
RPL is the 4th protocol standardized by IETF (RIP, OSPF, BGP)

Provides end-to-end IPv6 connectivity

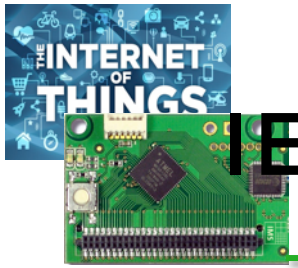
UDP can be used to transport sensor data



IoT FOR HUMAN



Internet of Things for you & me



IETF Internet for Things

CoAP: Constrained Application Protocol

UDP, TCP?

RPL
Routing Protocol for Low power & Lossy Networks

6LowPan
802.15.4

IPv6 egde router

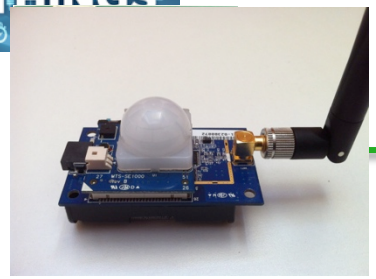
LBR (6lowPAN)

CoAP HTTP

TCP, UDP

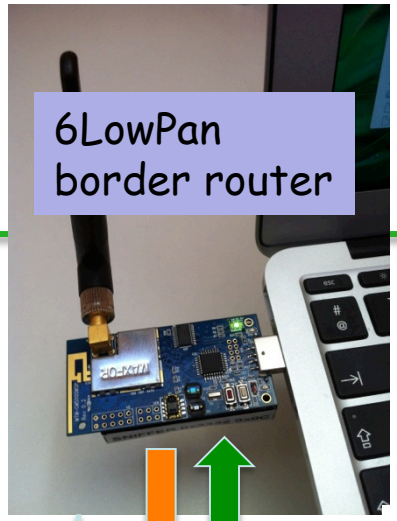
Internet Routing Protocols: RIP, OSPF, BGP,…

IPv4, IPv6



get

ack



CoAP/6LowPan/IEEE 802.15.4

RPL routing

IPv6

ack

get

Wi Fi

Client/User-initiated scenario (e.g. temp. sensor)

INTERNET

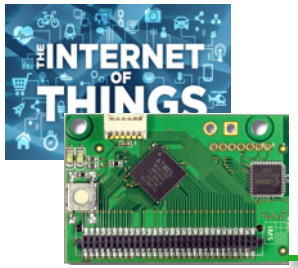
ack

IPv6

get

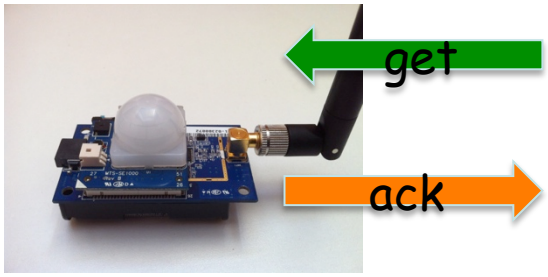
112	106.575520000	fe80::212:6d45:50b7:6a0f	fe80::212:6d45:5026:34cc	ICMPv6	94	RPL Control (Destination Advertisement Object),
113	106.576064000			IEEE 802.15.4	5	Ack, Bad FCS
114	106.576608000			IEEE 802.15.4	5	Ack, Bad FCS
115	113.692576000	fe80::212:6d45:50b7:7575	fe80::212:6d45:5026:34cc	ICMPv6	94	RPL Control (Destination Advertisement Object),
116	114.080416000	fe80::212:6d45:50b7:7575	[illegible]	ICMPv6	94	RPL Control (Destination Advertisement Object),
117	114.[illegible]			IEEE 802.15.4	5	Ack, Bad FCS
118	116.008352000	2001:620:607:5b10::a	::ff:fe00:28	COAP	60	Confirmable, GET, End of Block #15, Bad FCS
119	116.008896000			IEEE 802.15.4	5	Ack, Bad FCS
120	116.292576000	::ff:fe00:28	2001:620:607:5b10::a	COAP	65	Acknowledgement, 2.05 Content, End of Block #[illegible]
121	116.[illegible]			IEEE 802.15.4	5	Ack, Bad FCS
122	116.544800000	fe80::212:6d45:50b7:[illegible]	[illegible]	[illegible]	94	RPL Control (Destination Advertisement Object),
123	116.545344000			IEEE 802.15.4	5	Ack, Bad FCS
124	116.545888000			IEEE 802.15.4	5	Ack, Bad FCS
125	116.546432000			IEEE 802.15.4	5	Ack, Bad FCS
126	121.702624000	fe80::212:6d45:50b7:7e21	fe80::212:6d45:5026:34cc	ICMPv6	94	RPL Control (Destination Advertisement Object),
127	121.703168000			IEEE 802.15.4	5	Ack, Bad FCS
128	123.968480000	fe80::212:6d45:50b7:7575	fe80::212:6d45:5026:34cc	ICMPv6	94	RPL Control (Destination Advertisement Object),
129	123.969024000			IEEE 802.15.4	5	Ack, Bad FCS
130	127.058048000	fe80::212:6d45:50b7:69b3	fe80::212:6d45:50b7:6a0f	ICMPv6	94	RPL Control (Destination Advertisement Object),
131	127.058592000			IEEE 802.15.4	5	Ack, Bad FCS
132	127.344416000	fe80::212:6d45:50b7:6a0f	fe80::212:6d45:5026:34cc	ICMPv6	94	RPL Control (Destination Advertisement Object),

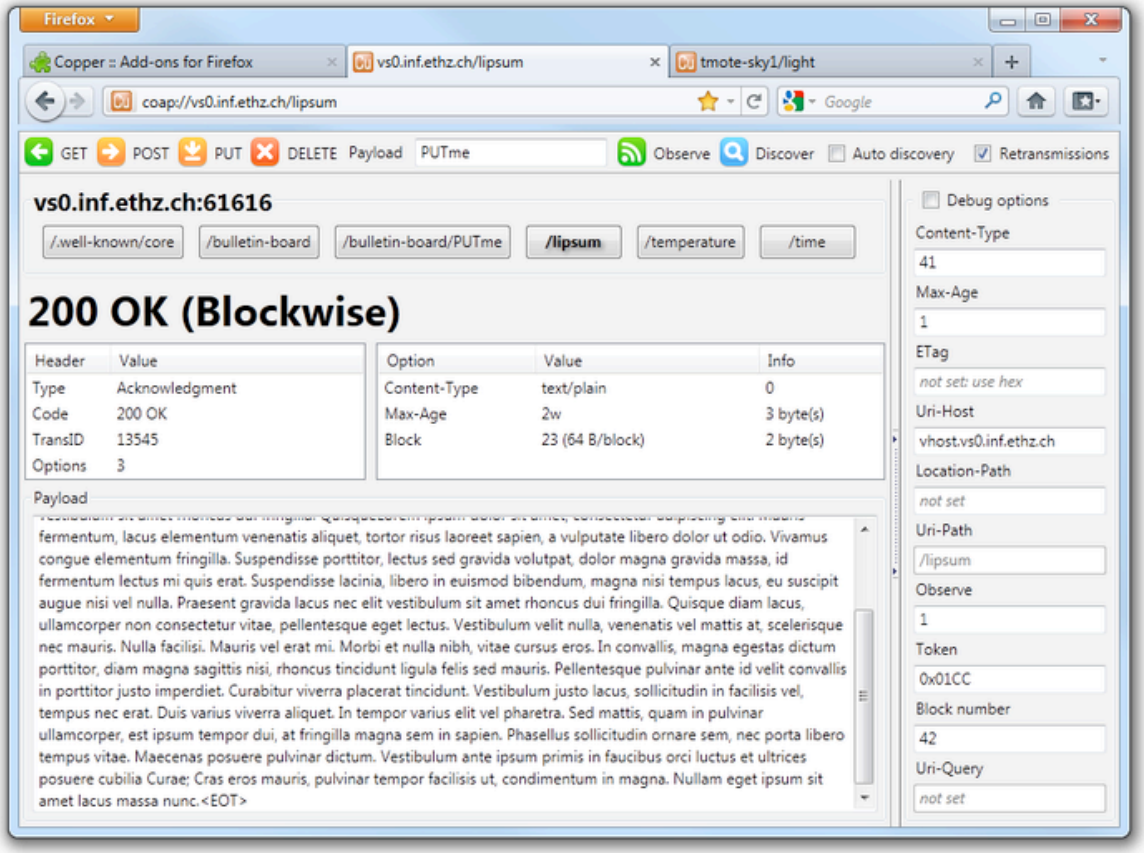
to actuators

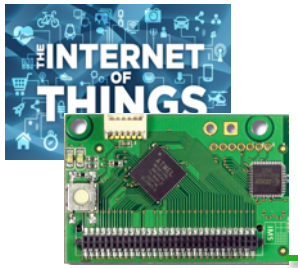


Copper for Firefox

- CoAP pluggin to query CoAP nodes in an HTTP-like fashion







Back to Industrial

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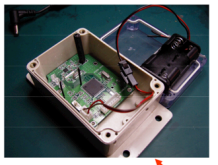
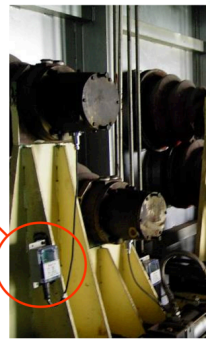
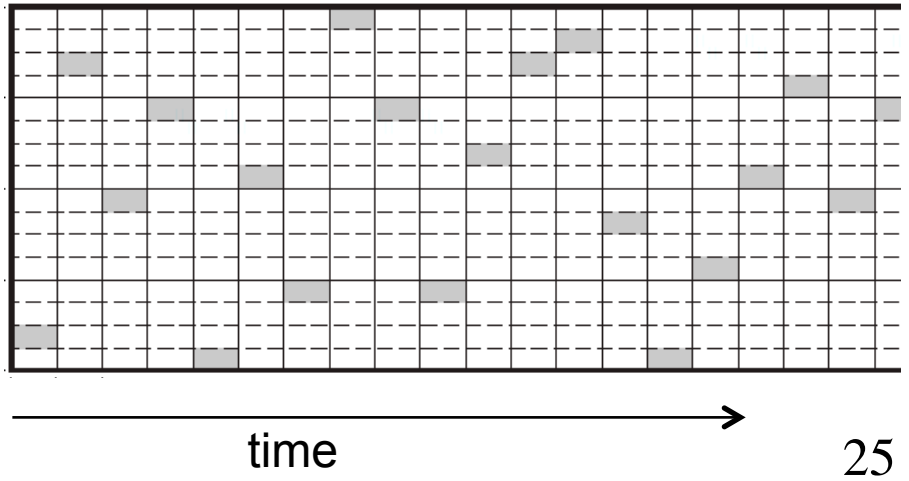


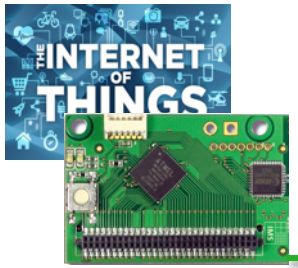


- Placement constraints
- Lifetime constraints

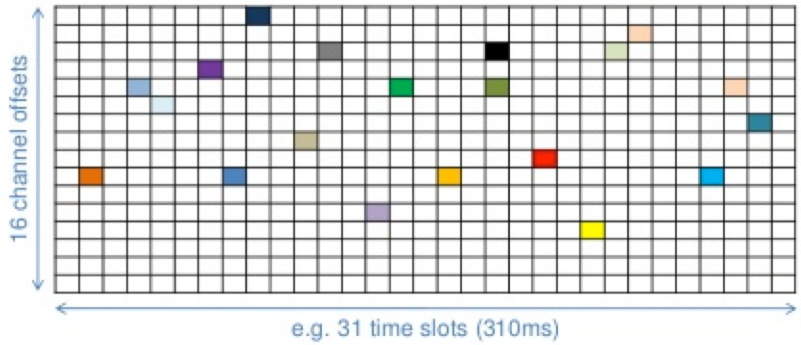
IEEE 802.15.4 has been enhanced to provide more robustness & reliability with channel hopping technologies - TSCH

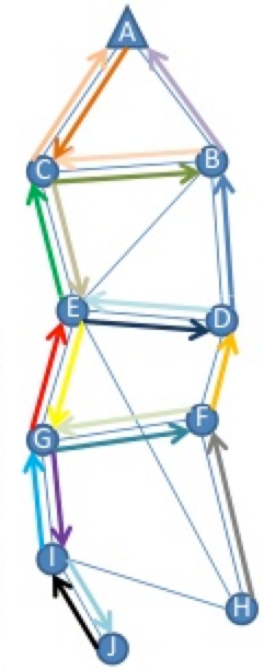
b) IEEE 802.15.4 channel selection (2400 MHz PHY)



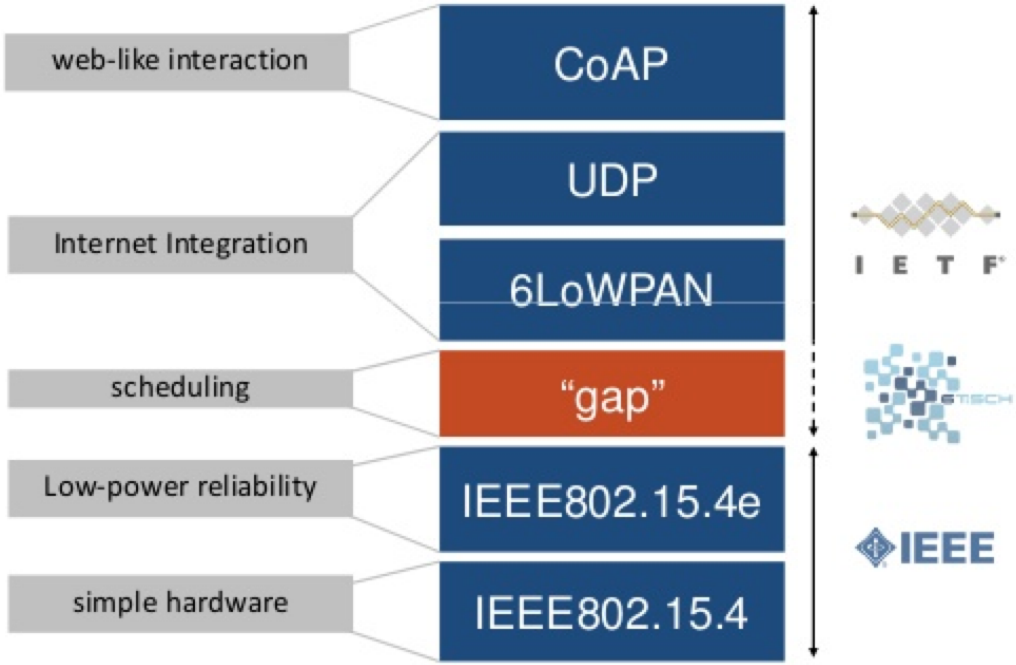


6LowPan / TSCH

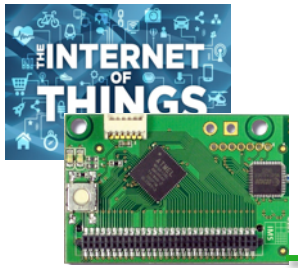




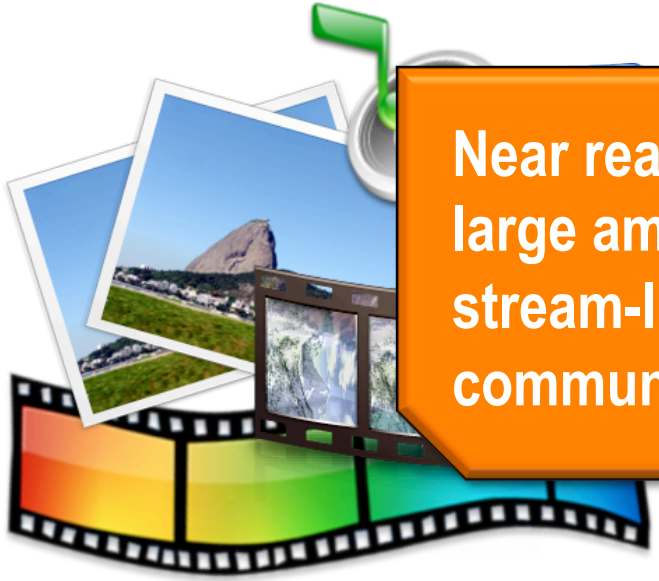
Figures from X. Vilajosana, "IETF 6TiSCH, a new standardization effort to combine IPv6 connectivity with industrial performance



IETF 6TiSCH addresses the issues of IPv6 over TSCH MAC

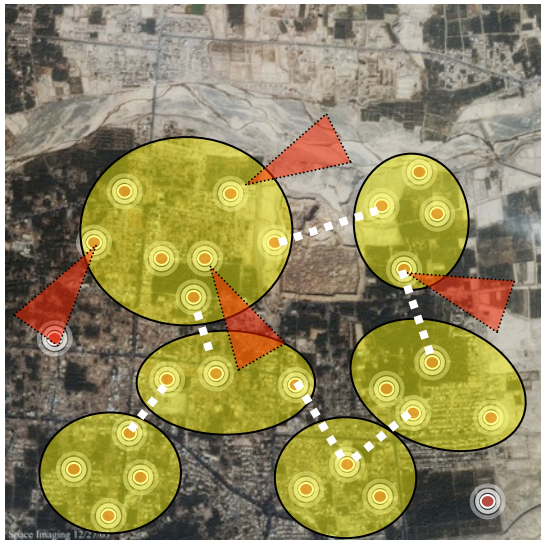


Towards Multimedia Information



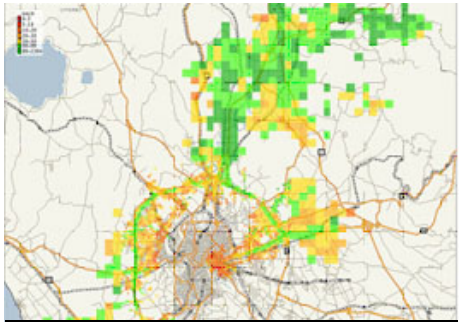
Near real-time constraints, large amount of data, stream-like communication,…

Visual data for situation-awareness



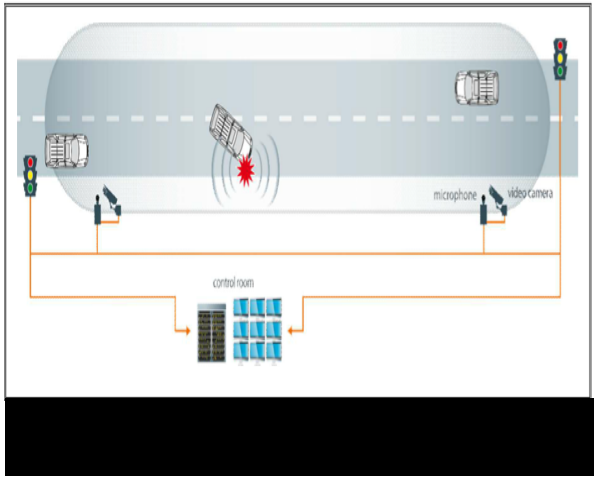
Collect data to improve the responsiveness of rescue operations

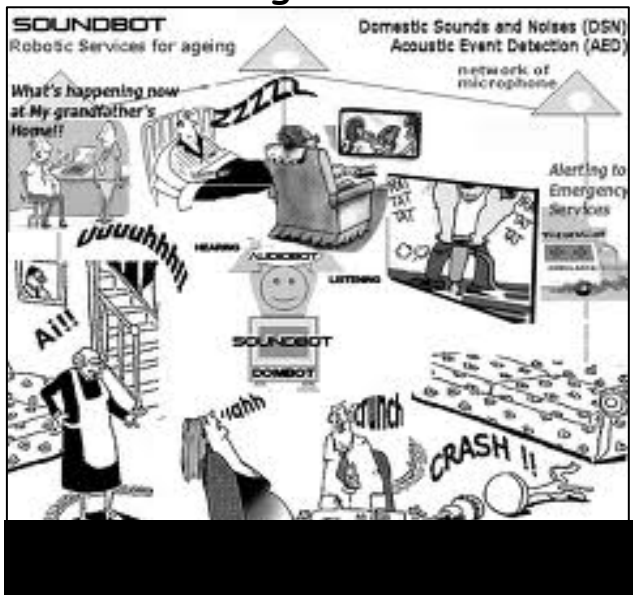
EXPLOITING ACOUSTIC DATA



Management

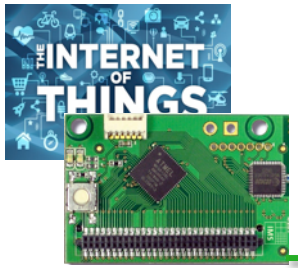
efficiency





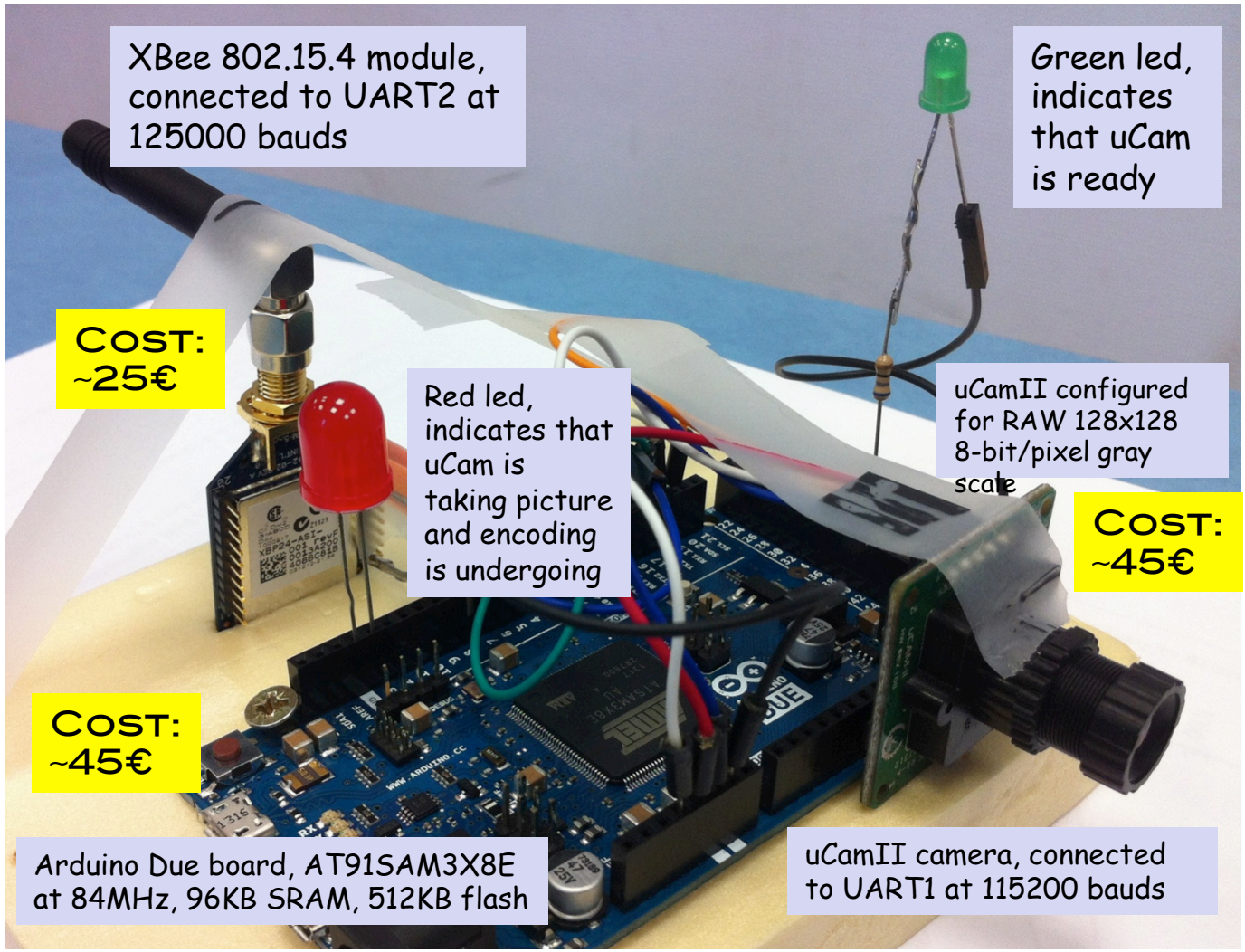
Surveillance

From EAR-IT slides



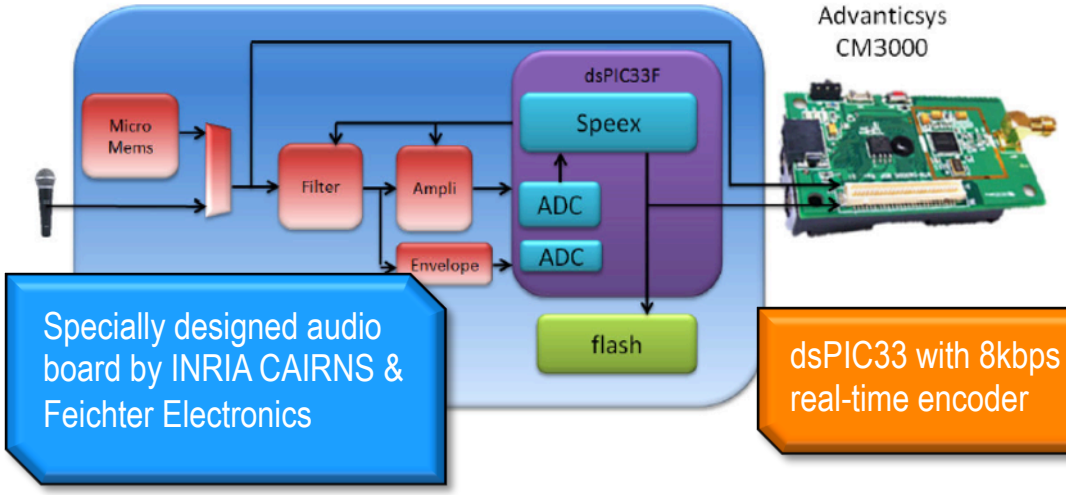
Arduino + uCamII
128x128 images

Can be controlled wirelessly to capture, take reference image, compare image, transmit image, define packet size, image quality factor,…

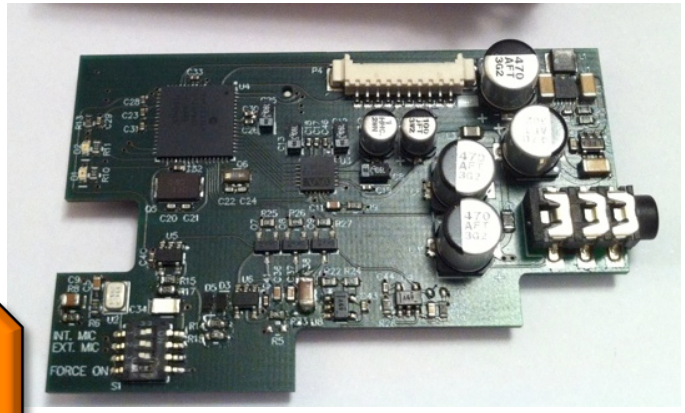


DEVELOPMENT OF AUDIO BOARD

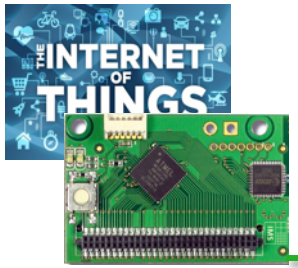
- USE DEDICATED AUDIO BOARD FOR SAMPLING/STORING/ENCODING



dsPIC33 with 8kbps speex real-time encoder



- ENCODING SCHEME IS SPEEX AT 8KBPS
- DESIGNED FOR MULTI-PLATFORM MOTES
- CAN BE PLUGGED TO OTHER BOARDS (UART)

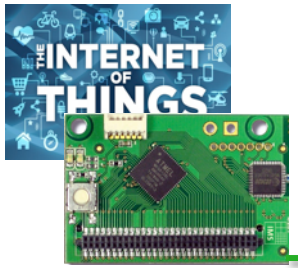


Communication performance issues?

- Application level performances depends on OS, API, hardware architecture
- Usually MUCH LOWER than radio performances!
- What are min. latencies & max. throughput?
  - For sending?
  - For receiving?
  - For relaying?

C. Pham, "Communication performance of low-resource sensor motes for data-intensive applications ", Proceedings of the IFIP Wireless Days International Conference (WD'2013), Valencia, Spain, November 2013.

C. Pham, "Communication performances of IEEE 802.15.4 wireless sensor motes for data-intensive applications: a comparison of WaspMote, Arduino MEGA, TelosB, MicaZ and iMote2 for image surveillance", Journal of Network and Computer Applications (JNCA), Elsevier, Vol. 46, Nov. 2014



Conclusions

- Internet of Things, like Wireless Sensor Networks are the foundation of pervasive surveillance infrastructures
- Connecting them, collecting data and providing seamless internet connectivity is challenging but many standards have emerged
- Going beyong « simple » data to multimedia is still challenging on these low-resource platforms