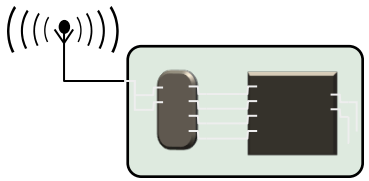
Remote Sensing for Disaster Management

Marco Zennaro — ICTP Trieste-Italy

Wireless sensor networks

- A Wireless Sensor Network is a self-configuring network of small sensor nodes communicating among themselves using radio signals, and deployed in quantity to sense, monitor and understand the physical world.

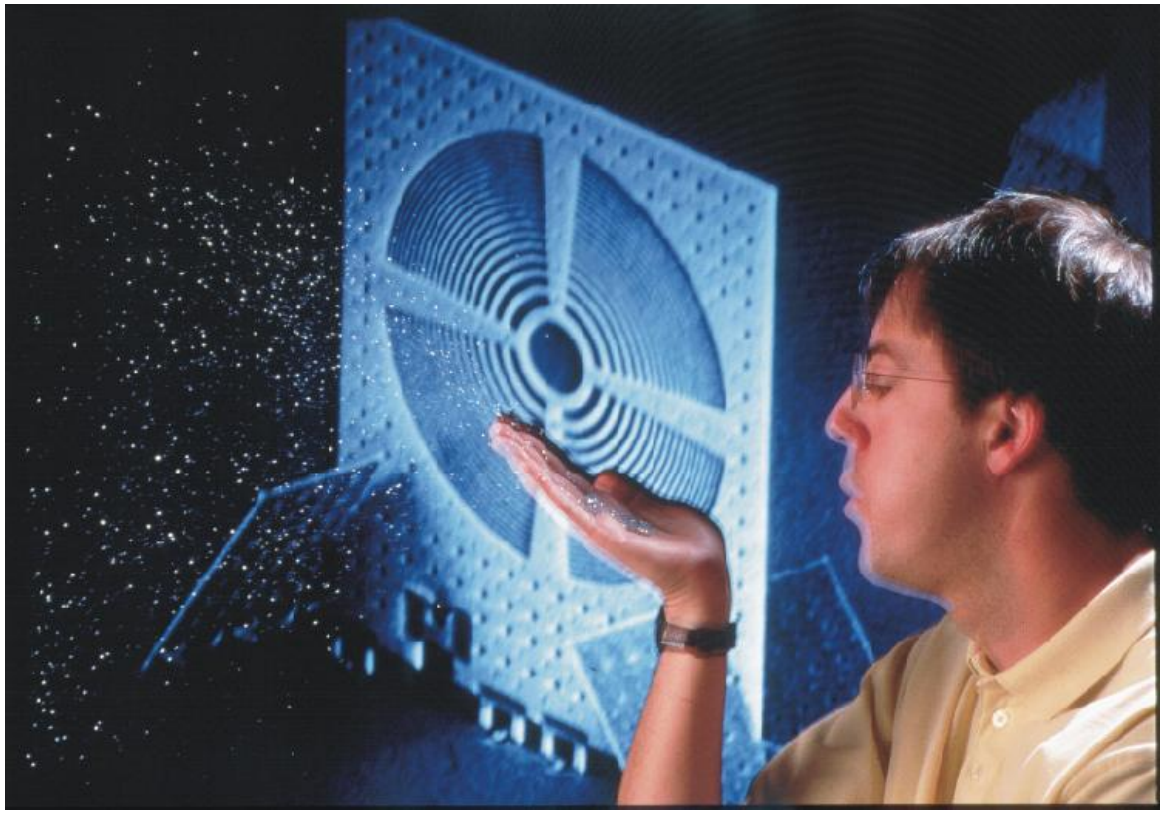
- Wireless Sensor nodes are called **motes.**



Wireless sensor networks

- WSN provide a bridge between the physical and the virtual worlds.
- Allow the ability to observe the previously unobservable at a fine resolution over large spatio-temporal scales.
- Have a wide range of potential applications to industry, science, transportation, civil infrastructure, and security.

Wireless sensor networks



Next Century Challenges: Mobile Networking for "**Smart Dust**"

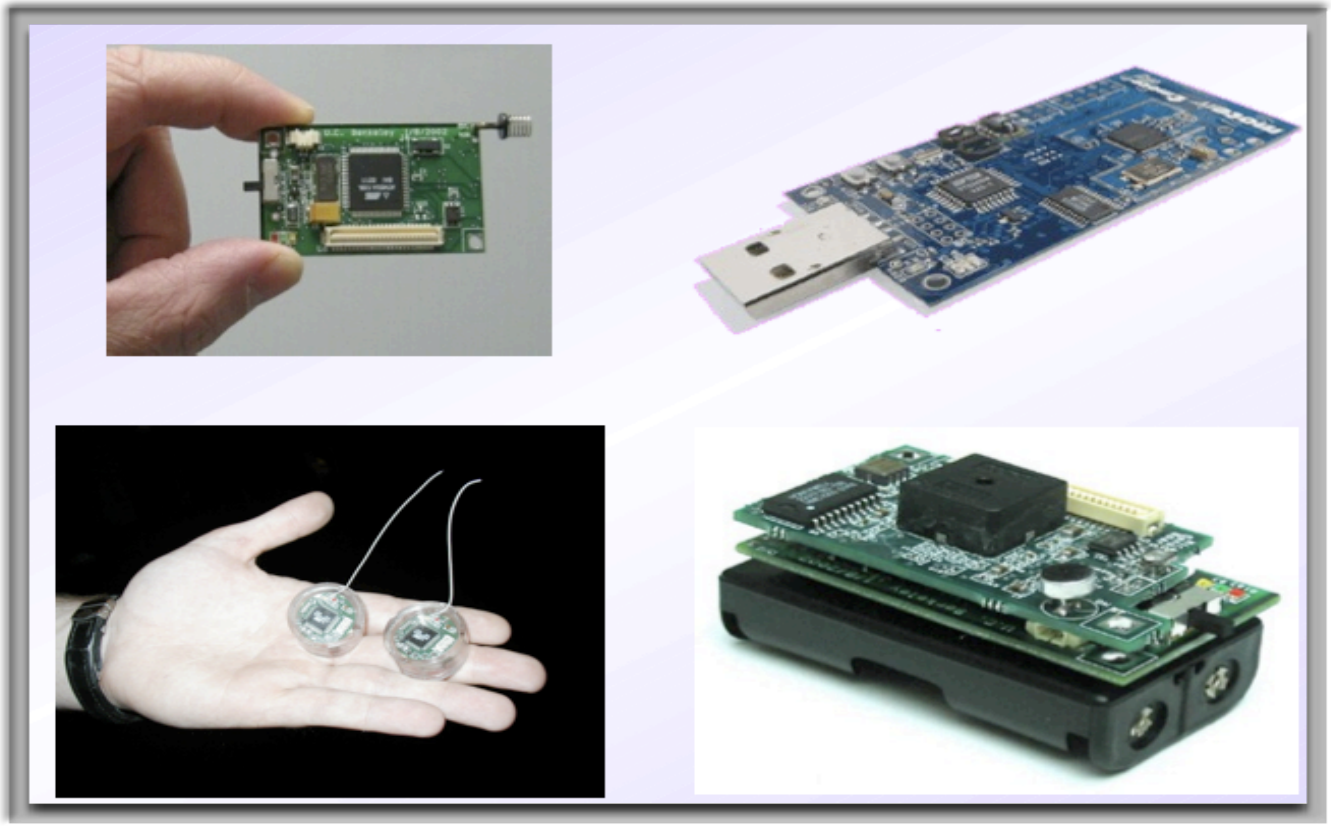
J. M. Kahn,

R. H. Katz,

K. S. J. Pister

(MobiCom 1999)

Mote Anatomy

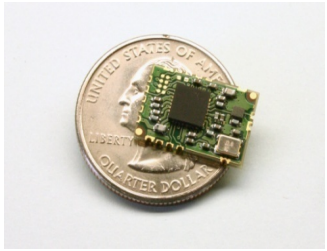


Mote Anatomy

- **Processor** in various modes (sleep, idle, active)
- **Power source** (AA or Coin batteries, Solar Panels)
- **Memory** used for the program code and for in-memory buffering
- **Radio** used for transmitting the acquired data to some storage site
- **Sensors** for temperature, humidity, light, etc

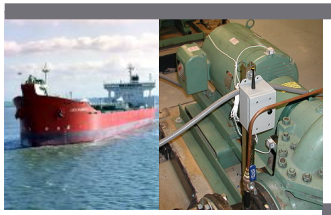
Mote Anatomy

- These motes are highly constrained in terms of
  - Physical size
  - CPU power
  - Memory (few tens of kilobytes)
  - Bandwidth (Maximum of 250 KB/s, lower rates the norm)



- Power consumption is critical
  - If battery powered then energy efficiency is paramount
  - Batteries might have to last for years
- May operate in harsh environments
  - Challenging physical environment (heat, dust, moisture, interference)

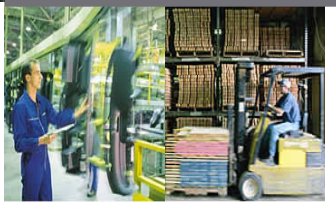
A World of Sensors



Predictive Maintenance

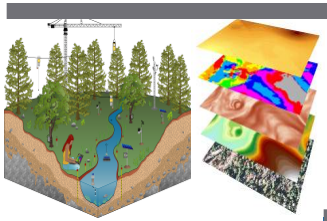
Energy Saving Smart Grid

High-Confidence Transport and Asset Tracking



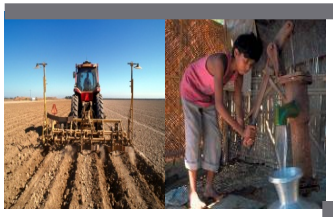
Improve Productivity

Intelligent Buildings



Enable New Knowledge

Enhanced Safety & Security



Improve Food and H_2O

Healthcare

Smart Home

Assets of WSN

- **Ad hoc networking:** does not rely on any existing infrastructure and does not incur in extra communication costs
- **Low cost:** no big budget
- **Unattended operation:** technical expertise is limited, maintenance free operation
- **Real-time response:** very useful in places with poor road conditions and limited communication infrastructure
- **Ease of deployment:** given by wireless

Wireless communication

- There are fourways to communicate data gathered by a WSN:

  1) Zigbee/802.15.4
  2) Low Power WiFi
  ~~3) GPRS~~
  4) Satellite

- Low power consumption is a driving requirement, so Zigbee/802.15.4 are the most popular standards.

Wireless communication: 802.15.4

- 802.11 – Wireless Local Area Networks (WiFi)
  - 802.11a, 802.11b, 80211g, 802.11n
- 802.15 – Wireless Personal Access Networks (WPAN)
  - Task Group 1 – Bluetooth (802.15.1)
  - Task Group 2 – Co-existence (802.15.2)
  - Task Group 3 – High Rate WPAN (802.15.3)
  - Task Group 4 – Low Rate WPAN (802.15.4 or 802.15 TG4)
  - Task Group 5 – Mesh Networking (802.15.5)
- 802.16 – Wireless Metropolitan Area Networks (WiMax)
- 802.20 – Mobile Broadband Wireless Access (Mobile-Fi) - Defunct
- 802.22 – Wireless Regional Access Network (WRAN)
  - Utilise free space in the allocated TV spectrum

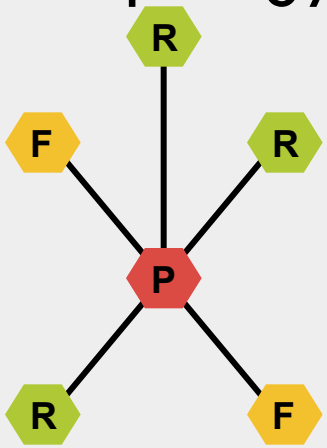
Wireless communication: 802.15.4

- Channels:
  - 868.0 - 868.6MHz -> 1 channel (Europe)
  - 902.0-928.0MHz -> 10 channels (EEUU)
  - 2.40-2.48GHz -> 16 channels (Worldwide)

- Bit Rates:
  - 868.0 - 868.6MHz -> 20/100/250 Kb/s
  - 902.0-928.0MHz -> 40/250 Kb/s
  - 2.40-2.48GHz -> 250 Kb/s

IEEE 802.15.4 Topologies

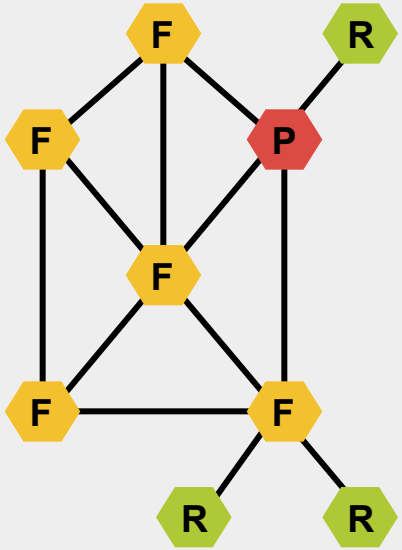
Star Topology



All devices communicate to PAN co-ordinator which uses mains power

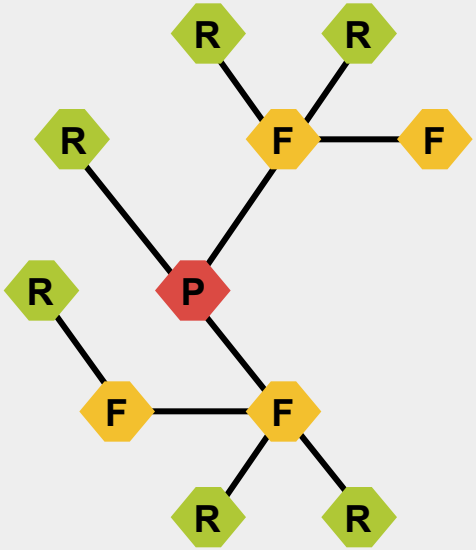
Other devices can be battery/scavenger

Mesh Topology



Devices can communicate directly if within range

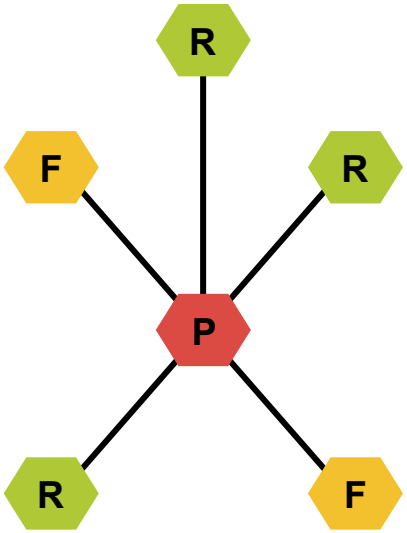
Cluster Tree



Higher layer may create their own topology that do not follow 802.15.4 topologies

Single PAN co-ordinator exists for all topologies

Gateway based design



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802.15.4

WiFi/Ethernet

WSN and Disaster Management

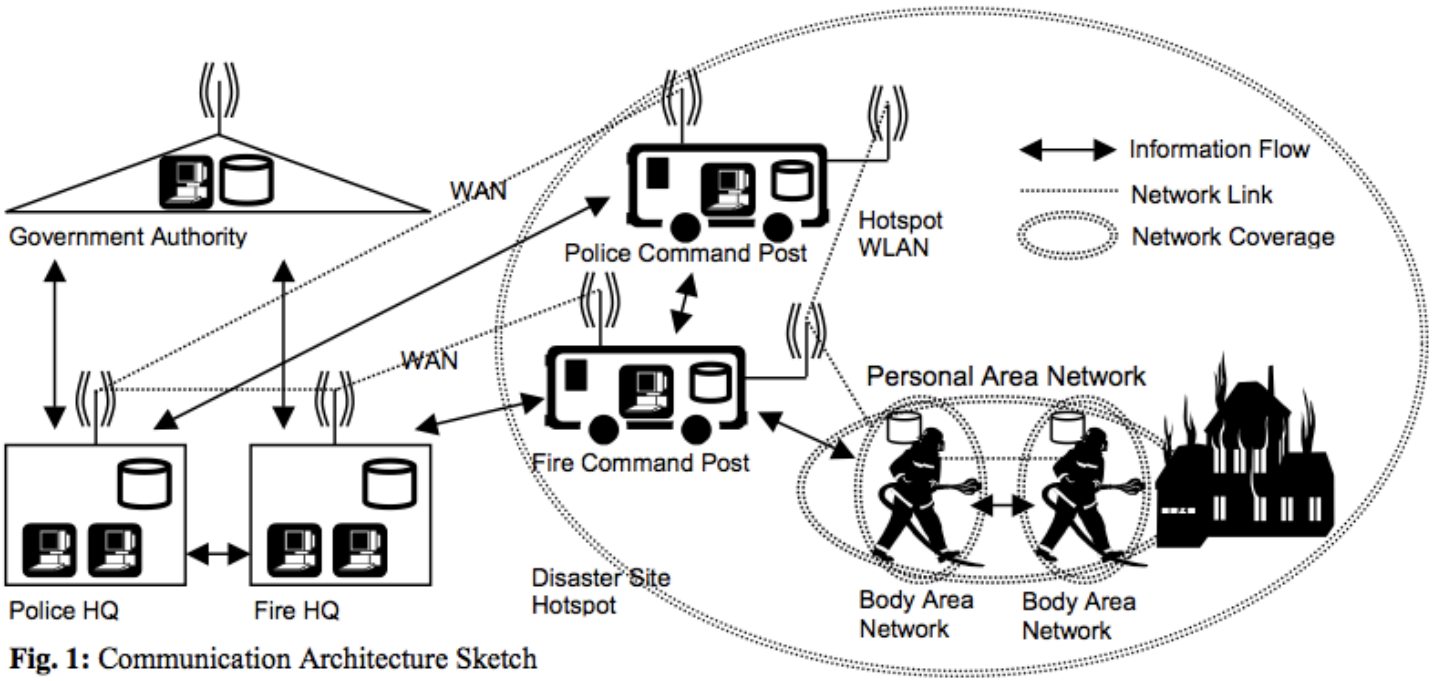
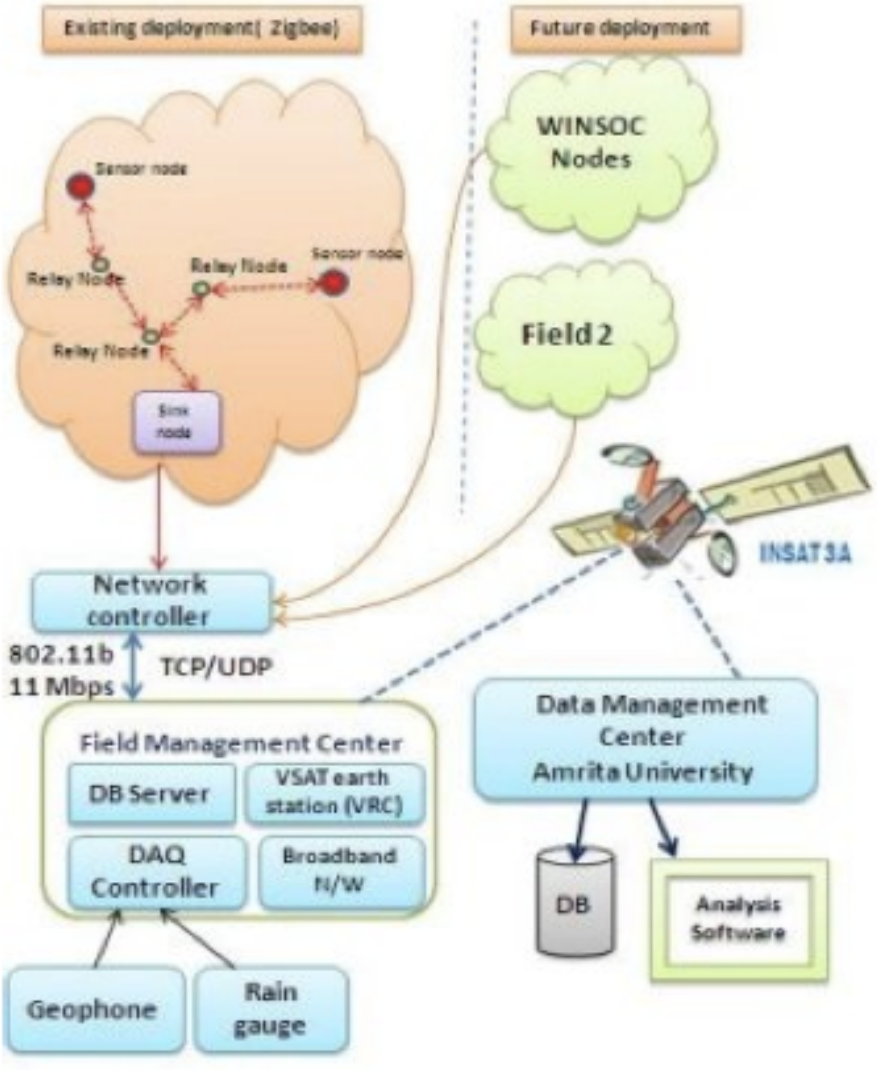


Fig. 1: Communication Architecture Sketch

Design Challenges for an Integrated Disaster Management Communication and Information System
Andreas Meissner , Thomas Luckenbach , Thomas Risse , Thomas Kirste , Holger Kirchner, DIREN 2002

WSN and Disaster Management



Wireless Sensor Network for Landslide Detection
Maneesha V. Ramesh, Sangeeth Kumar, and P. Venkat Rangan
SENSORCOMM 2009

Wireless communication: 802.11

- Low power 802.11 is a new technology, very promising for Disaster Management.
- **Advantage: use the same standard as WiFi networks.**
- High power Wi-Fi chips are optimized for fast response, low latency, and high data rates.
- Low power Wi-Fi chips are optimized for low power consumption, particularly when the device is in Standby mode.

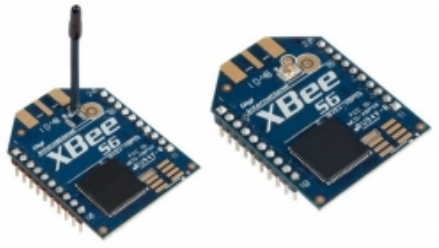
WiFi based WSN

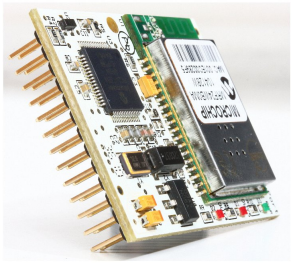
WiFi based WSN

Parameter		Conventional Wi-Fi	Low-Power Wi-Fi	units
Power consumption	Standby / Idle	NA*	<4	µW
	Processor + clock sleep	13	0.2	mW
	Data processing	115	56	mW
Receive sensitivity, 1 Mbps		-91	-91	dBm
Time to wake from Standby		NA*	10	ms
Time to wake from processor+clock sleep		75	5	ms

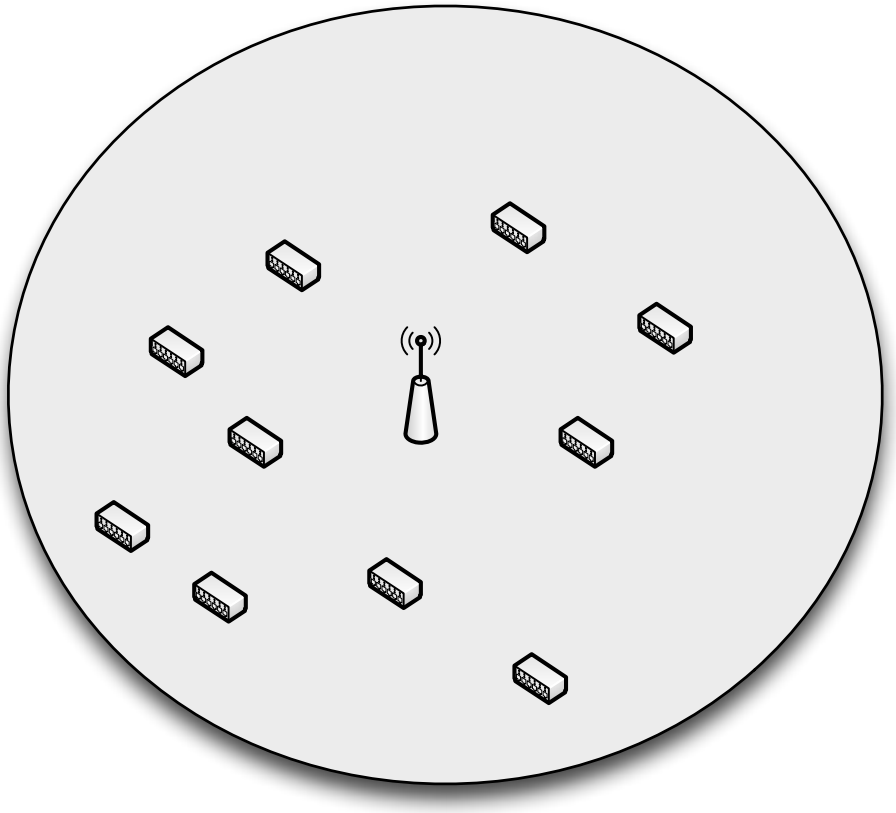
WiFi based WSN

- Examples
  - The **XBee Wi-Fi** modules from Digi International come in 1mW and 2mW versions.
  - The **Flyport** provides the following services: Webserver (even Ajax apps can be run), TCP Socket, UDP Socket, SMTP Client.
  - The **Gainspan** modules.

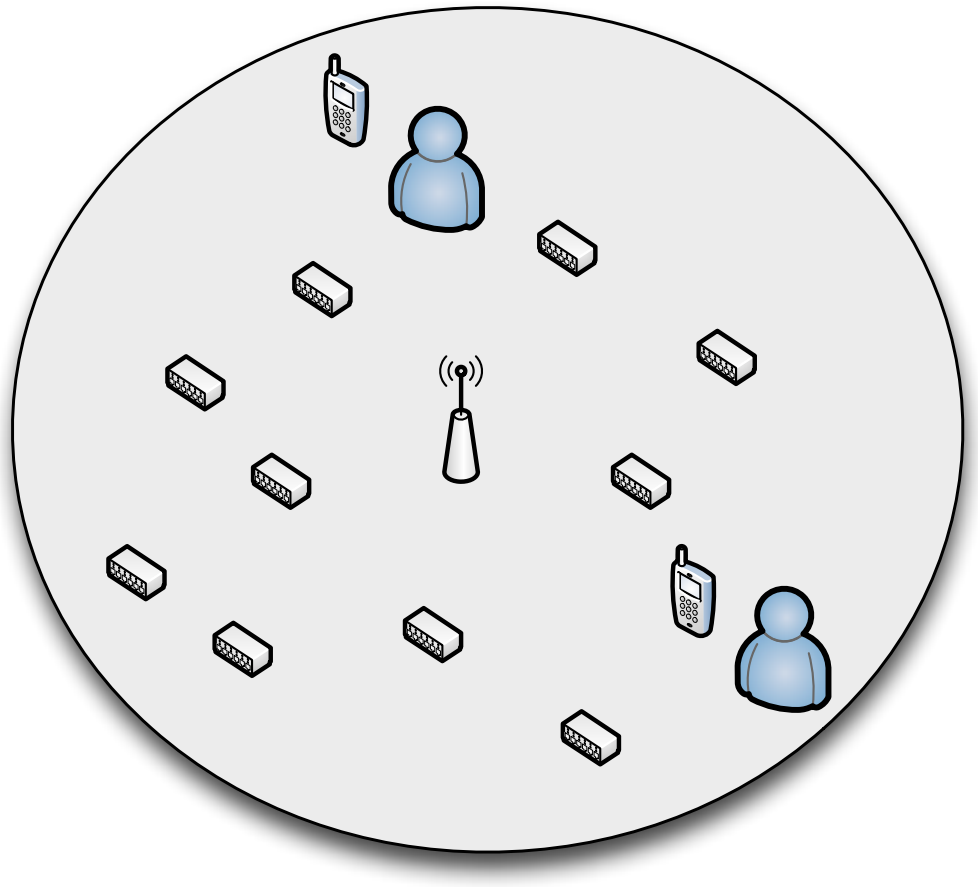




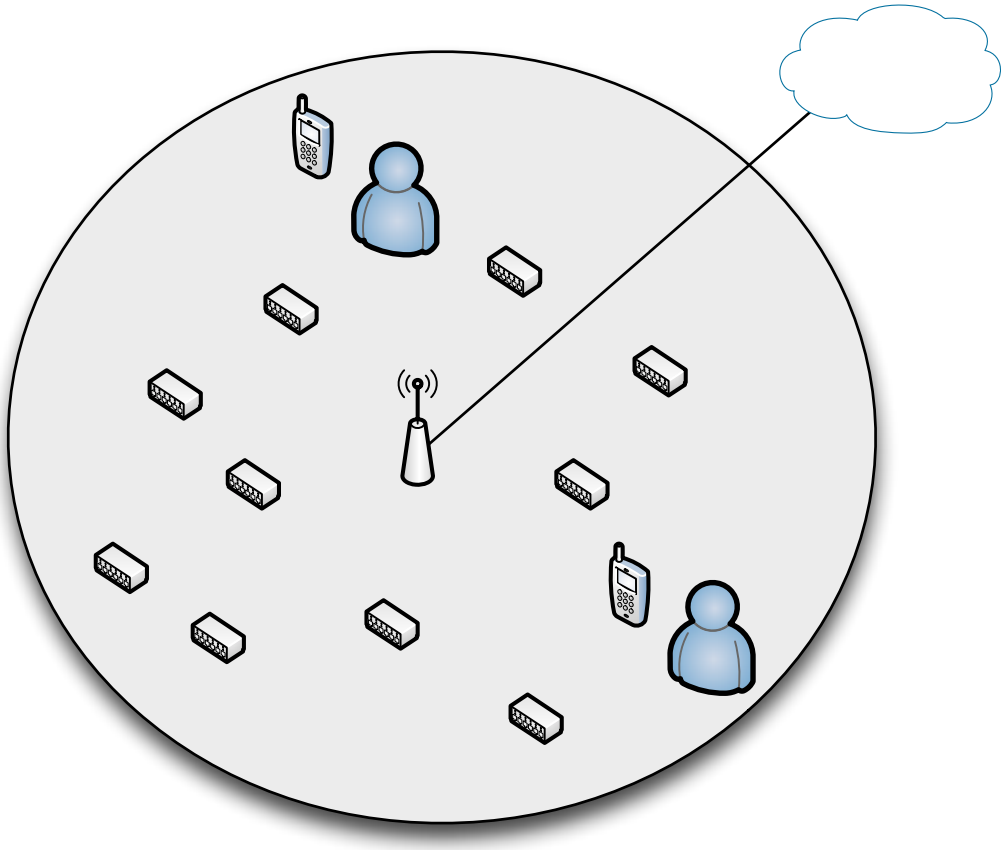
WiFi based WSN



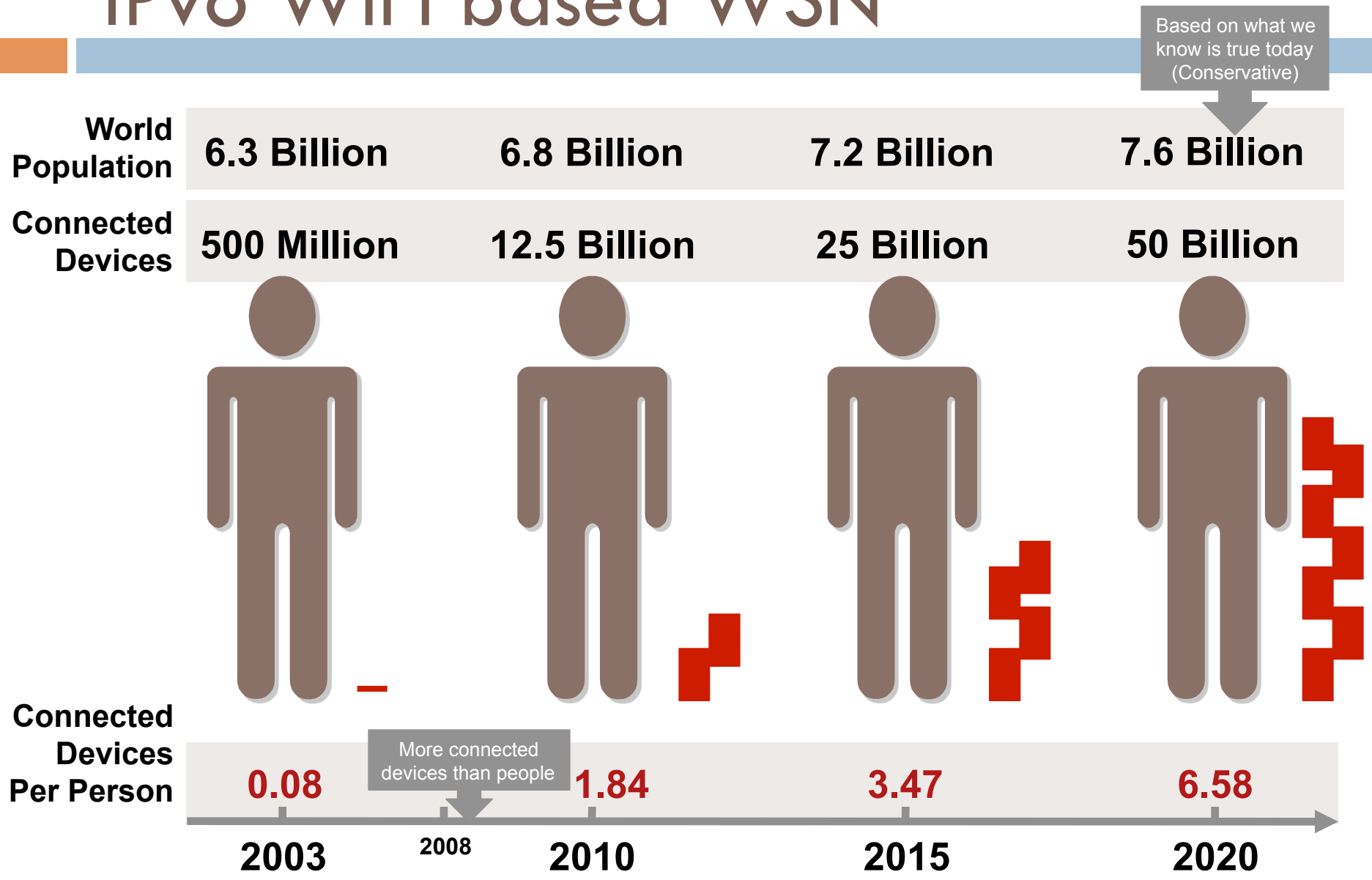
WiFi based WSN + VoIP



WiFi based WSN + VoIP + Internet



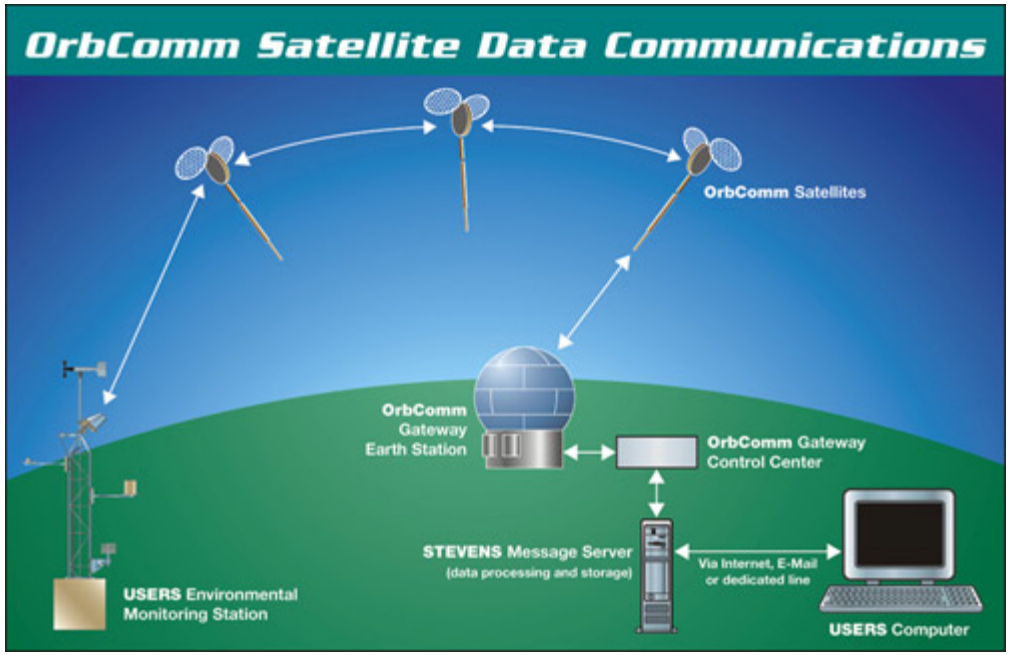
IPv6 WiFi based WSN



Satellite for WSN

- This used to be an expensive and power hungry solution.
- **Advantage: deployable anywhere.**
- Global LEO satellite coverage (no blockage).
- Extremely compact module form factor.
- Very low receive (60 mA max) and transmit power consumption (1.5 A max).

Satellite for WSN



Satellite for WSN

ICTP-ITU Marconi Lab

- We are a research institution, and the Marconi Lab is focused on low cost ICT solutions.
- We have been running WSN training activities in South Africa and Kenya. Next one in Ghana in December.
- We will test the satellite WSN solution for water management.

Credits

- Credits for the slides go to:
  - Bhaskar Raman
  - Muneeb Ali
  - Holger Karl
  - David Gascon
  - Antoine Bagula
  - Claro Noda
  - Jeff Apcar

Thanks

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