Ubiquitous and Secure Networks and Services

Redes y Servicios Ubicuos y Seguros

Unit 3: Architectures and Models

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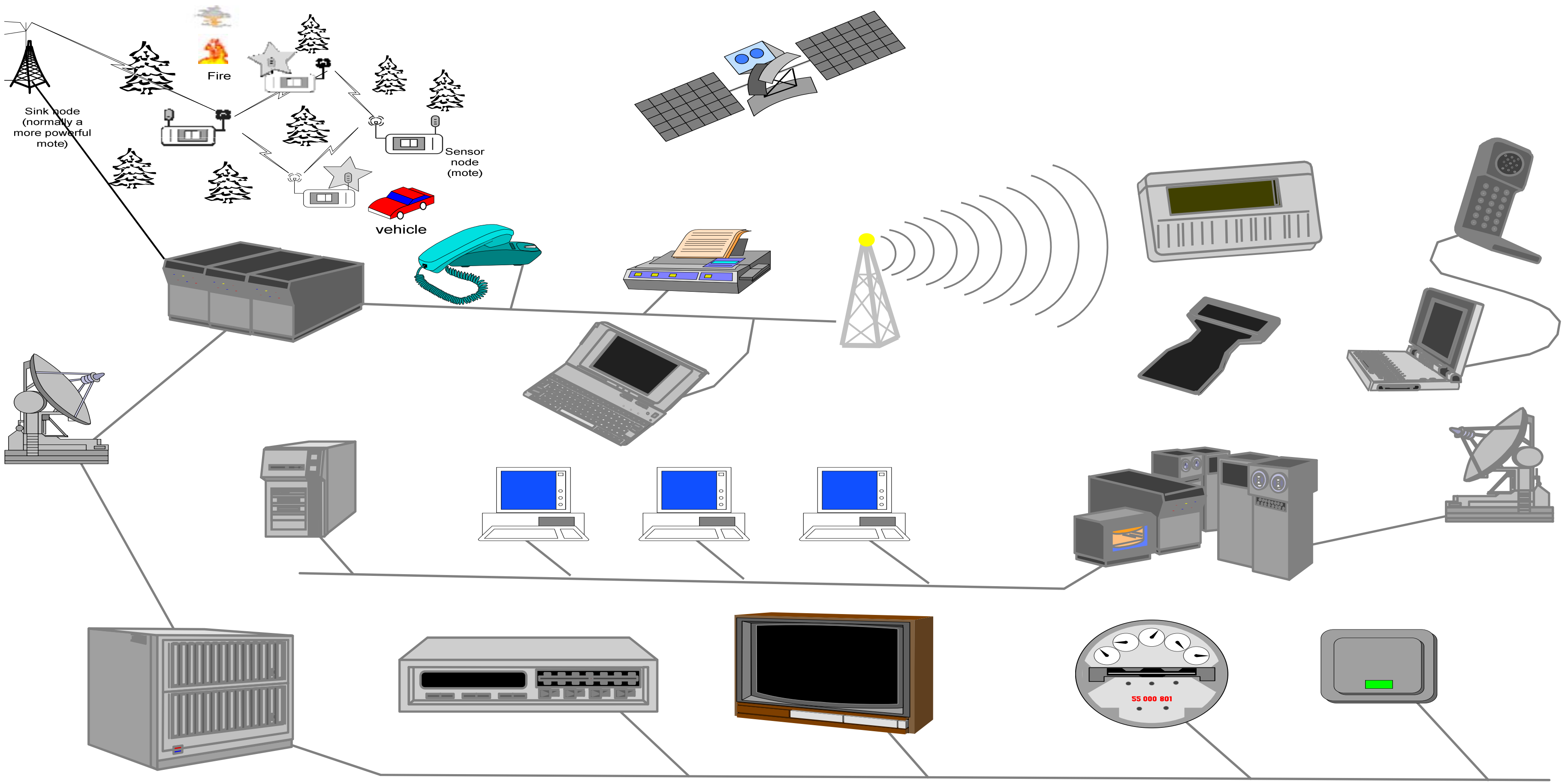
UNIT 3: Architectures and Models

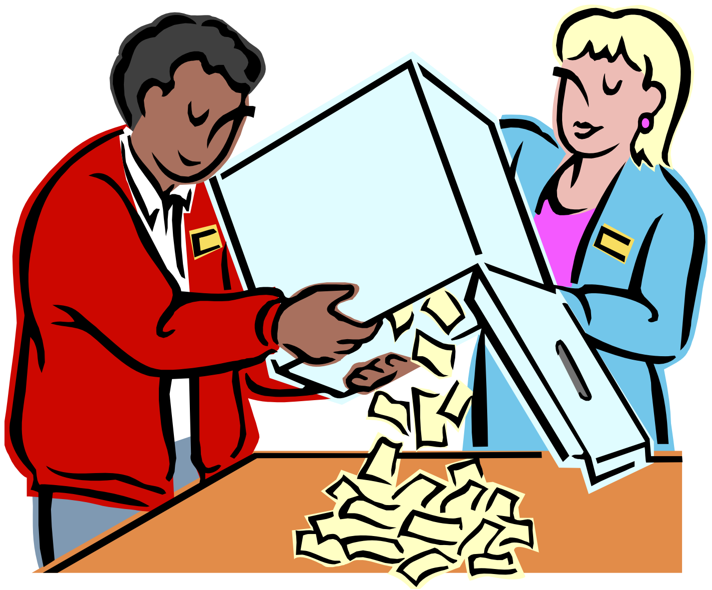
INTRODUCTION

Evolution to pervasive computing



Distributed System Features

- Heterogeneity
- Extensibility
- Security
- Scalability
- Fault management
- Concurrency
- Transparency

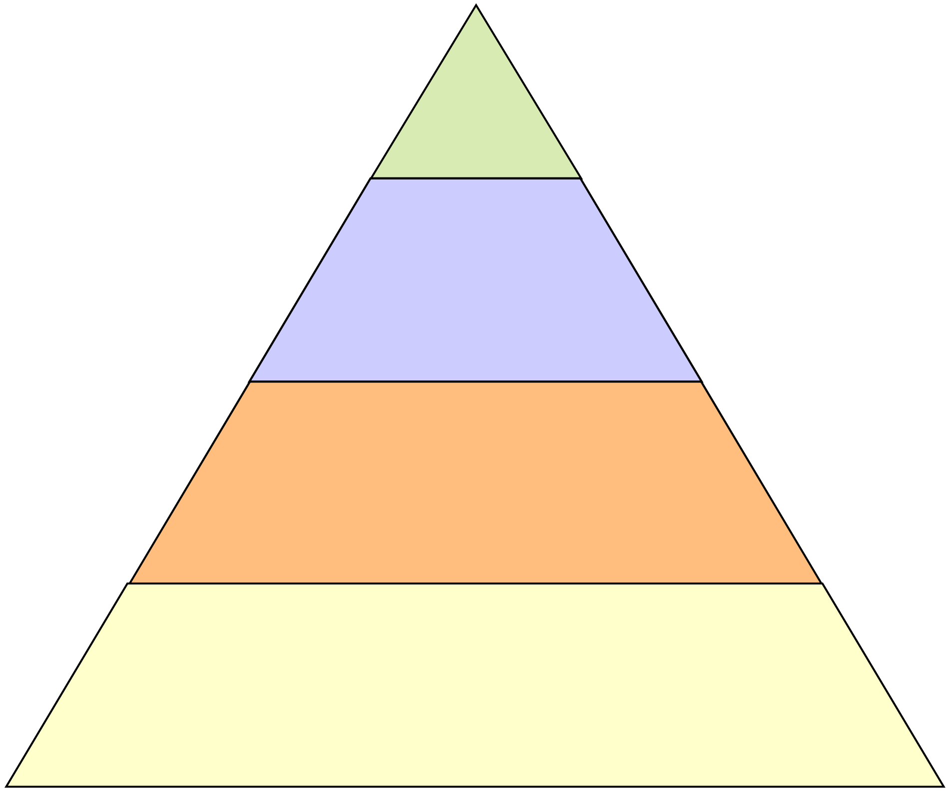


Architectural Models

- To identify the functionality of the simple system components.
- To manage problems associated to component localization in the network (distributed patterns, information, workload).
- To analyze relationships among components (communication patterns),
- Starting point:
  - Servers
  - Clients
  - Peer to Peer …

General Software Levels

- **Platform**
  - Hardware.
  - Operating System.
  - Low level software layers.
- ***Middleware***
  - "Heterogeneity problem".
- **Application and services**



Towards a Middleware approach

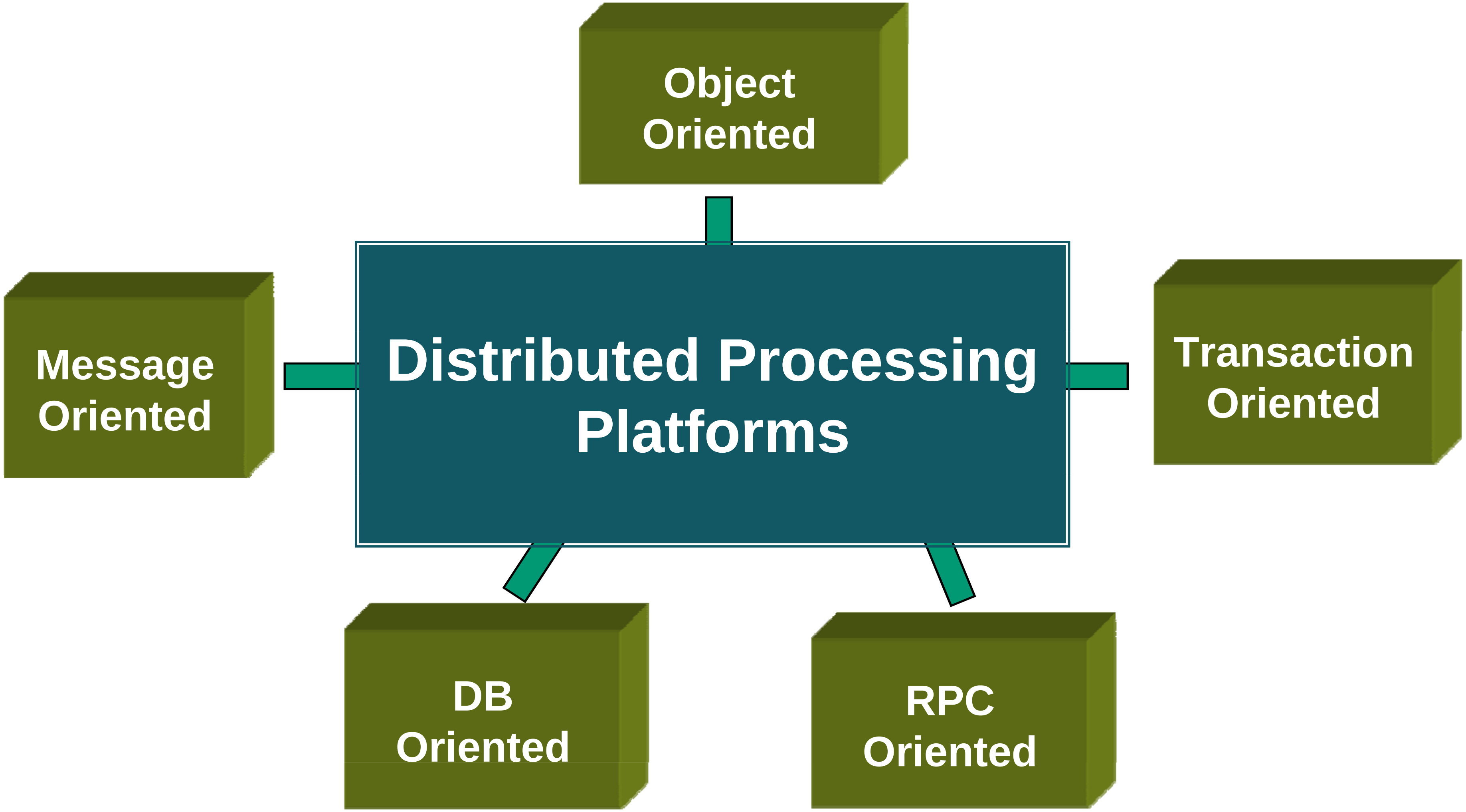
¿What is distributed cooperation?

Problem - "Heterogeneity"

Application/Service

Application/Service

Middleware Services

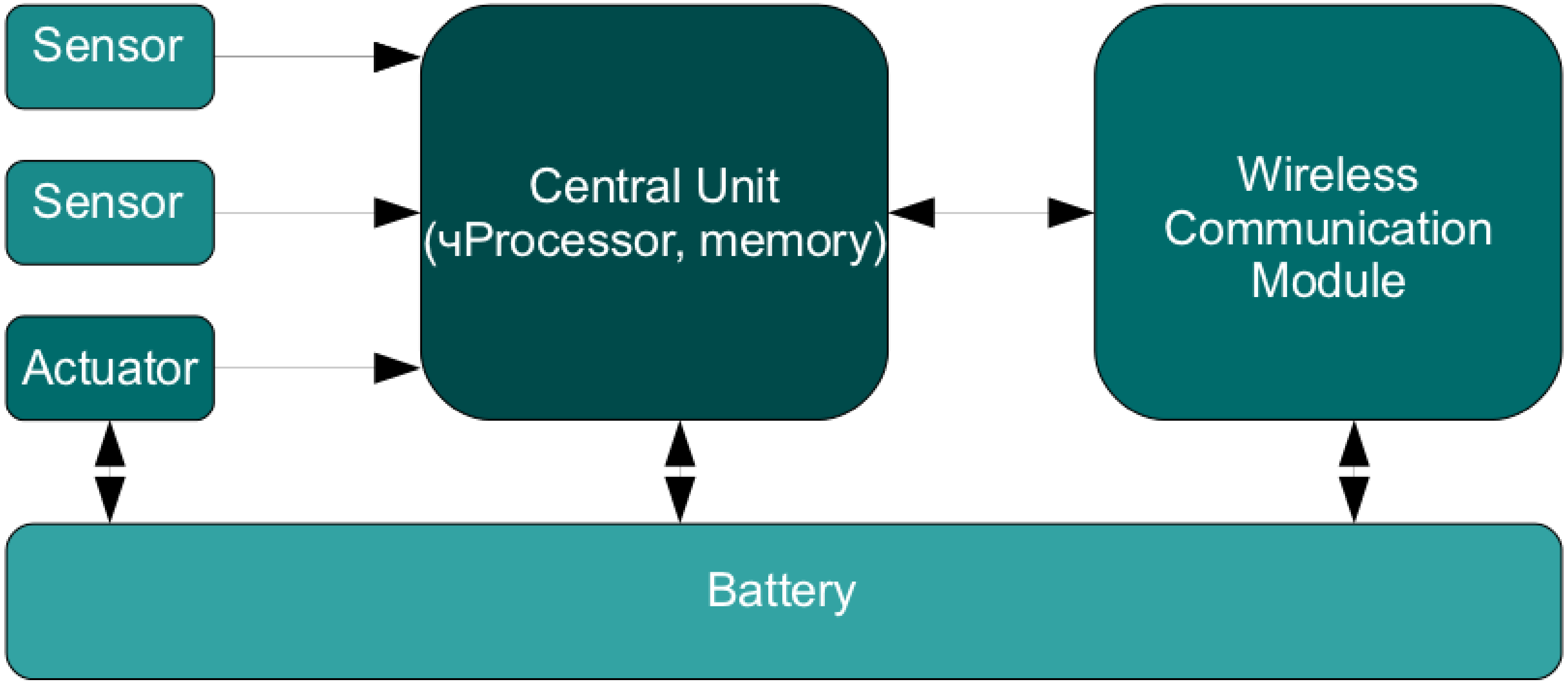


So…What about WSN?

UNIT 3: Architectures and Models

PLATFORM LAYER

Bird’s Eye View



Tmote Sky

- Developed in the Berkeley University.
- Features:
  - USB interface.
  - Built-in antenna – 125 mts.
  - Flash memory for software installation.

Tmote Sky

Processing Unit		Interfaces	
Microcontroller	MSP430F1611	Digital	6 GPIO
RAM	10 KB RAM	Analogical	6 ADC
ROM	48 KB (FLASH)	Serial	I2C, SPI, USB
Speed	8 MHz	Sensors	Humidity, light, temperature
Operating System	TinyOS and Contiki	Gateway	Ethernet

Radiofrequency		Others	
Transceiver	Chipcon CC2420	Power source	AA Batteries
Band	2400 – 2483.5 MHz	Power idle	5.1 uA
Bit rate	250 Kbps	Power (Rx/Tx)	19.5 mA / 21.8 mA
Modulation	O-QPSK	Cost	Unit 130 $
Range	(out-door), (in-door)	Gateway	Tmote Connect
Protocol	802.15.4	Licence	BSD (Op. System)
Security	802.15.4	Extras	None

Crossbow Family

- Monitorization and data acquisition
  - Radio 916 MHz -2.4 GHz (ZigBee compliant)
  - Different HW and SW platforms
  - Families:
    - First Generation (MICAz, MICA 2, Telos B)
    - Second Generation (Imote 2)

Different Crossbow motes. More information at www.xbow.com. Used under Crossbow's terms of use: http://www.xbow.com/terms-of-use.html.

Imote 2

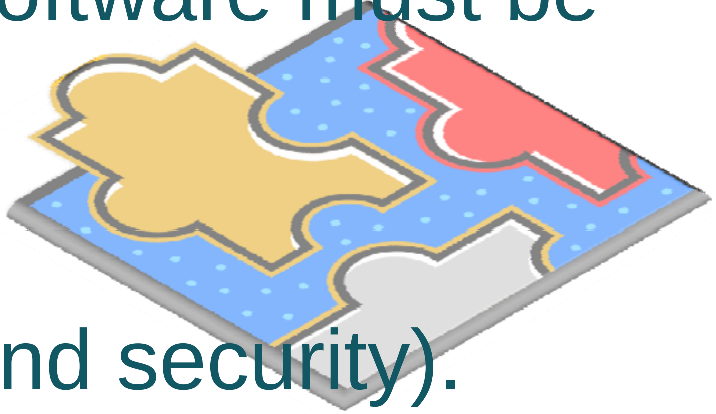
Processing Unit		Interfaces	
Microcontroller	Intel PXA271	Digital	DIO
RAM	256 KB	Analogical	8 x ADC
ROM	32 MB (FLASH)	Serial	3 UART, 2 I2C, 2 SPI, , SDIO, GPIO
Speed	13-416 MHz	Sensors	Sensor plug-in interface
Operating System	TinyOS	Gateway	Mini-USB(local) or Ethernet (base station)
Radiofrequency		**Others**	
Transceiver	CC2420	Power source	AA Batteries
Band	2.4 GHz	Power idle	31 uA
Bit rate	250 Kbps	Power (Rx/Tx)	44 mA / 44 mA
Modulation	O-QPSK	Cost	404 $ unit
Range	75-(out-door), 20- (in-door)	Gateway	None
Protocol	No specified	Licence	BSD (op. syst.)
Security	No specified	Extras	None

Radiofrequency Technologies

	Bluetooth	ZigBee	Z-wave	WiFi	Wavenis
Frecuency Band	2.4 GHz	2.4 GHz/ 5.2 GHz	868MHz 915MHz	2.4 GHz/ 5.2 GHz	433/868/915MHz (2,4GHz)
Data speed	1 Mbps	250 Kbps	few Kbps	5.5/11 MHz	4,8 / 19,2 / 250 Kbps
Deployment	☺☺☺	☹	☺	☺☺☺	☺☺
Reliability	☺☺☺	☺☺☺	☹	☺☺☺	☺☺☺
Low consumption	☺	☺☺	☺☺	☹	☺☺☺
Range	☹	☹	☺	☺	☺☺☺
Low cost	☺	☺☺	☺☺	☹	☺☺☺
Range in-door	☹ (10m)	☹ (20m)	☺ (50m)	☺ (50m)	☺☺☺ (until 200m)
Standard protocol	☺☺☺	☺☺☺	☹	☺☺☺	☺☺
Availability	☺☺☺	☹	☺☺☺	☺☺☺	☺☺☺

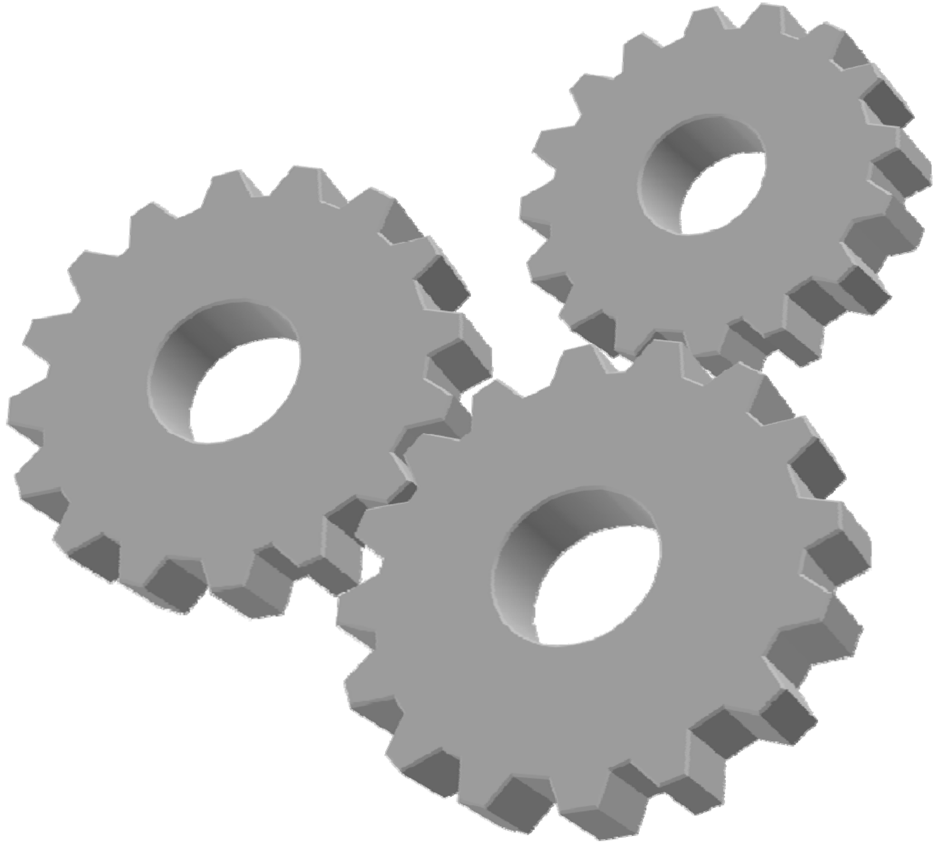
Open issues

- Size vs. costs.
- Integration of new functionalities (circuits).
- New encapsulation formats.
- New personalized solutions.
- Power consumption (harvesting).
- MAC, HW components and software must be improved.
- Consumption reduction.
- Uncorrelated antennas.
- Reliability (embedding QoS and security).



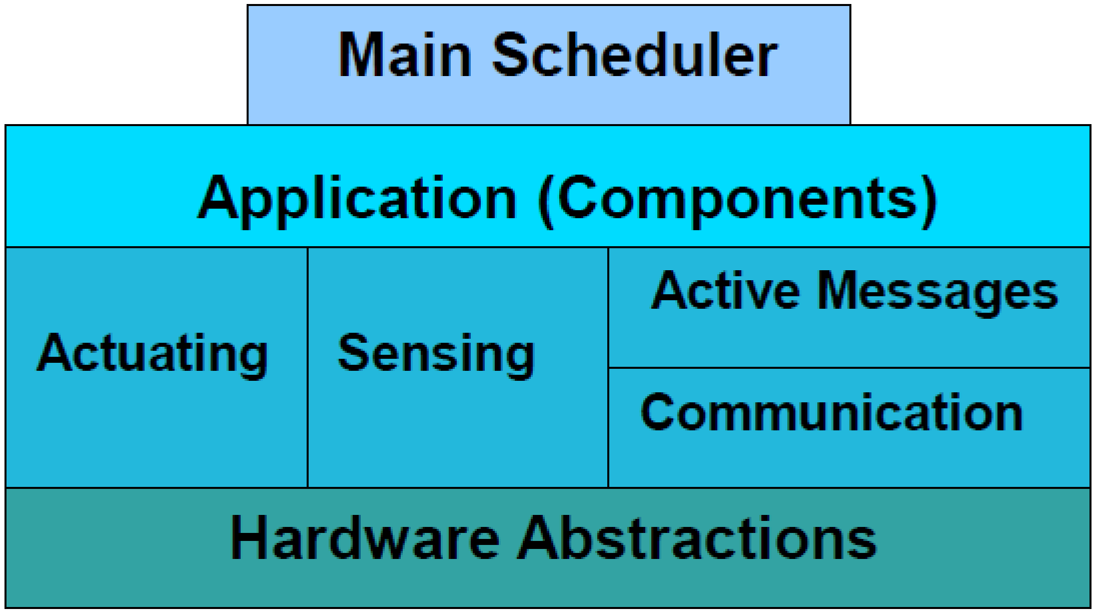
Operating Sytems

- Contiki
- MagnetOS
- SOS
- ***TinyOS***
- Squawk



TinyOS - Berkeley

- Application = scheduler + graph of components.
  - Compiled into one executable.
- Event-driven architecture.
- Single shared stack.
- No kernel/user space differentiation.



UNIT 3: Architectures and Models

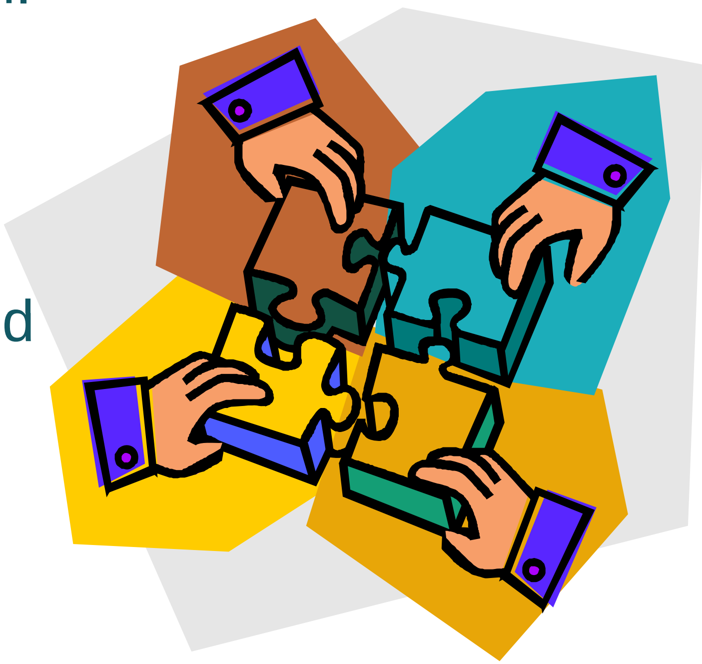
MIDDLEWARE LAYER

WSN Software Technologies

- Design Analysis for WSN.
  - Distribution.
  - Data source availability.
  - Bandwidth and resources.
  - Cooperating applications.
  - Quality of Service (QoS).
  - Security.

Middleware at whole!!

- Middleware must provide:
  - Appropriate interfaces for a wide range of applications.
  - Run-time environment for coordination.
  - Mechanisms to achieve efficient resource use.



- Middleware services:
  - Independency of network services and low level layers.
  - Facilities for interacting with other in-network applications.
  - Increase availability and reliability.
  - Guaranteeing scalability.

WSN Middleware Features

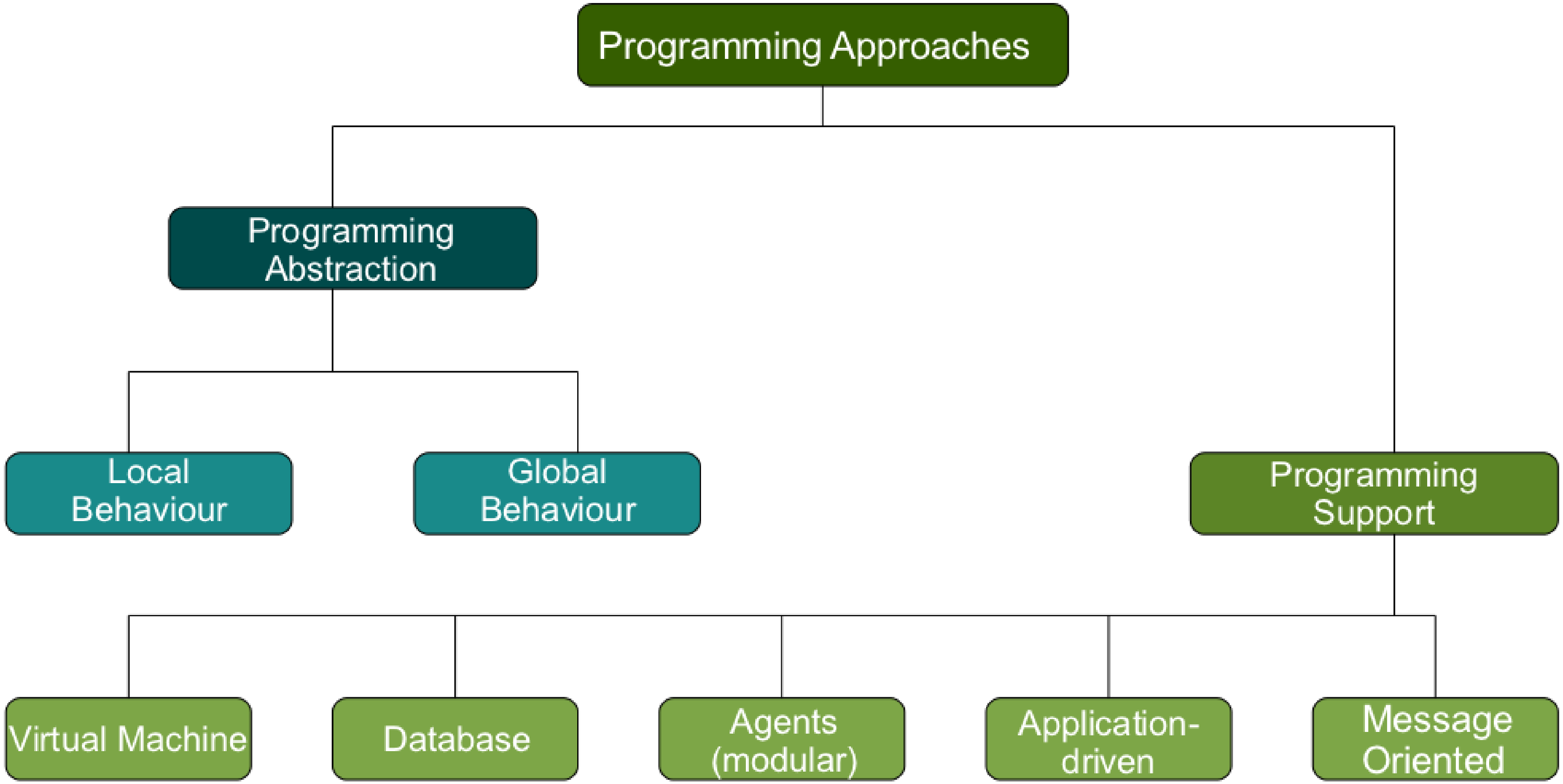
- Nodes are small-scale devices.
- Nodes and sensors (actuators) are limited by power supply (batteries) – Harvested!
- Nodes are likely to fail (batteries, environment).
- Nodes are resource constrained.

WSN Middleware Challenges

- Supporting the configuration lifecycle
- Working in network with thousands of nodes
- Providing abstraction of the network
- Fulfilling main requirements: energy efficient, reliability and scalability

- Allowing event-based or periodic communication
- Providing self-configuring and self-management
- Paying attention to the time and localization concepts
- Providing application knowledge in the WSN infrastructure
- Supporting real-time applications needs
- Supporting security issues

WSN Middleware Approaches



Maté – Virtual Machine

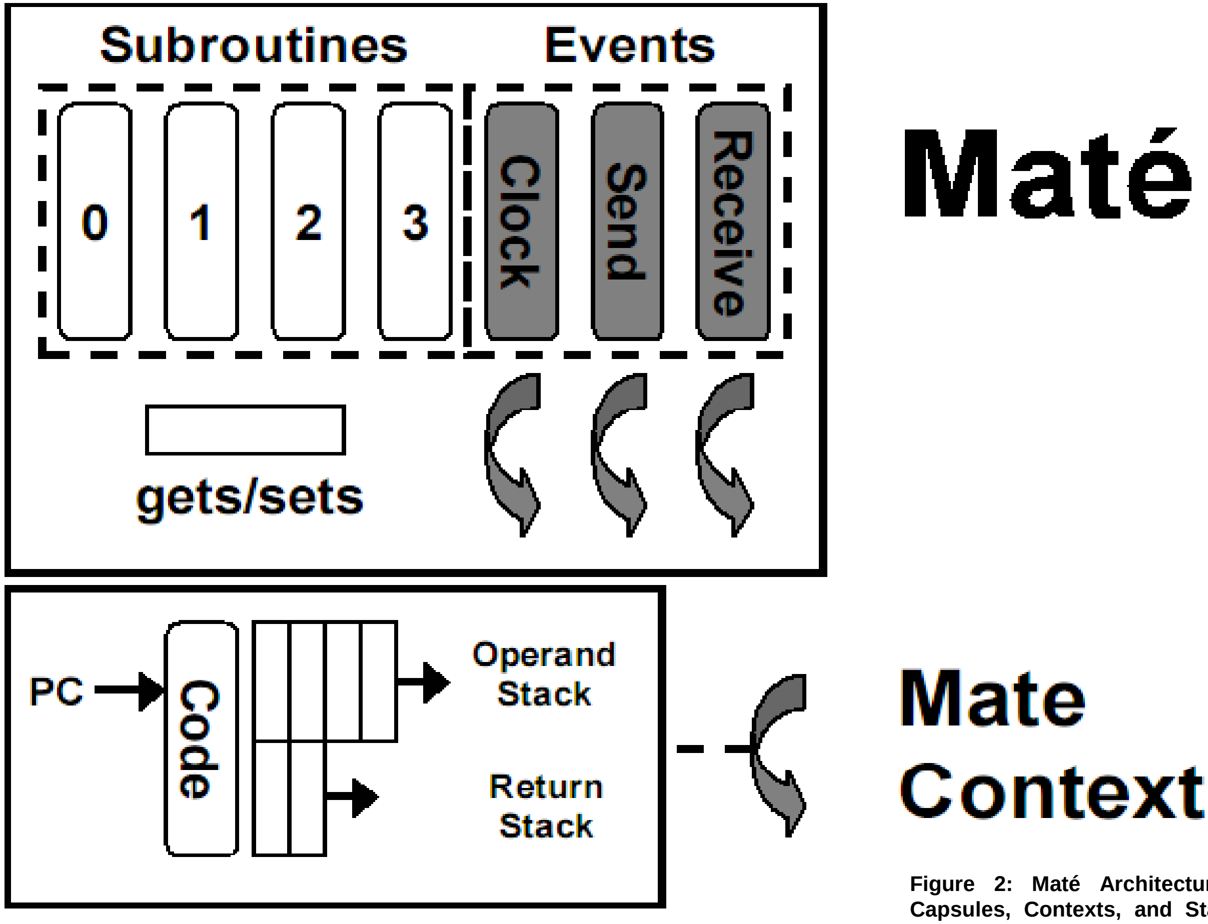


Figure 2: Maté Architecture and Execution Model: Capsules, Contexts, and Stacks. [Levis2002] Levis, P and Culler, D. “Maté: A Tiny Virtual Machine for Sensor Networks”. 10th International Conference on Architectural Support for Programming Languages (ASPLOS X), 2002.

Agents in WSN

	Agents	WSN Nodes
Autonomy	Capacity of maintain some task under control without external attention.	Capacity to reach objective without network intervention.
Asynchronous working capacity	Start to work when the agents receive some information.	It senses stimulus and reacts.
Collaboration and coordination	The agents exchange data for achieving a common task.	The nodes need to work together for reducing interactions among nodes.
Communication	Capacity to interaction with other agents.	Capacity to exchange data.
Objective driven	The agents can reach their objectives with some information.	The sensed data by the nodes are used in order to reach network goals
Reactivity	Capacity to provide a result when something happens.	Capacity to detect and react to unforeseen events.
Mobility	Capacity to migrate.	Capacity to migrate between nodes.

UNIT 3: Architectures and Models

USE CASE: AN EVENT-DRIVEN MIDDLEWARE: MICRO SUBSCRIPTION MANAGEMENT SYSTEM (µSMS)

Origin of This Middleware Approach

- The µSMS Middleware was developed as part of a project of the 6th Framework Programme:

  Solving Major Problems in Micro Sensorial Wireless Networks

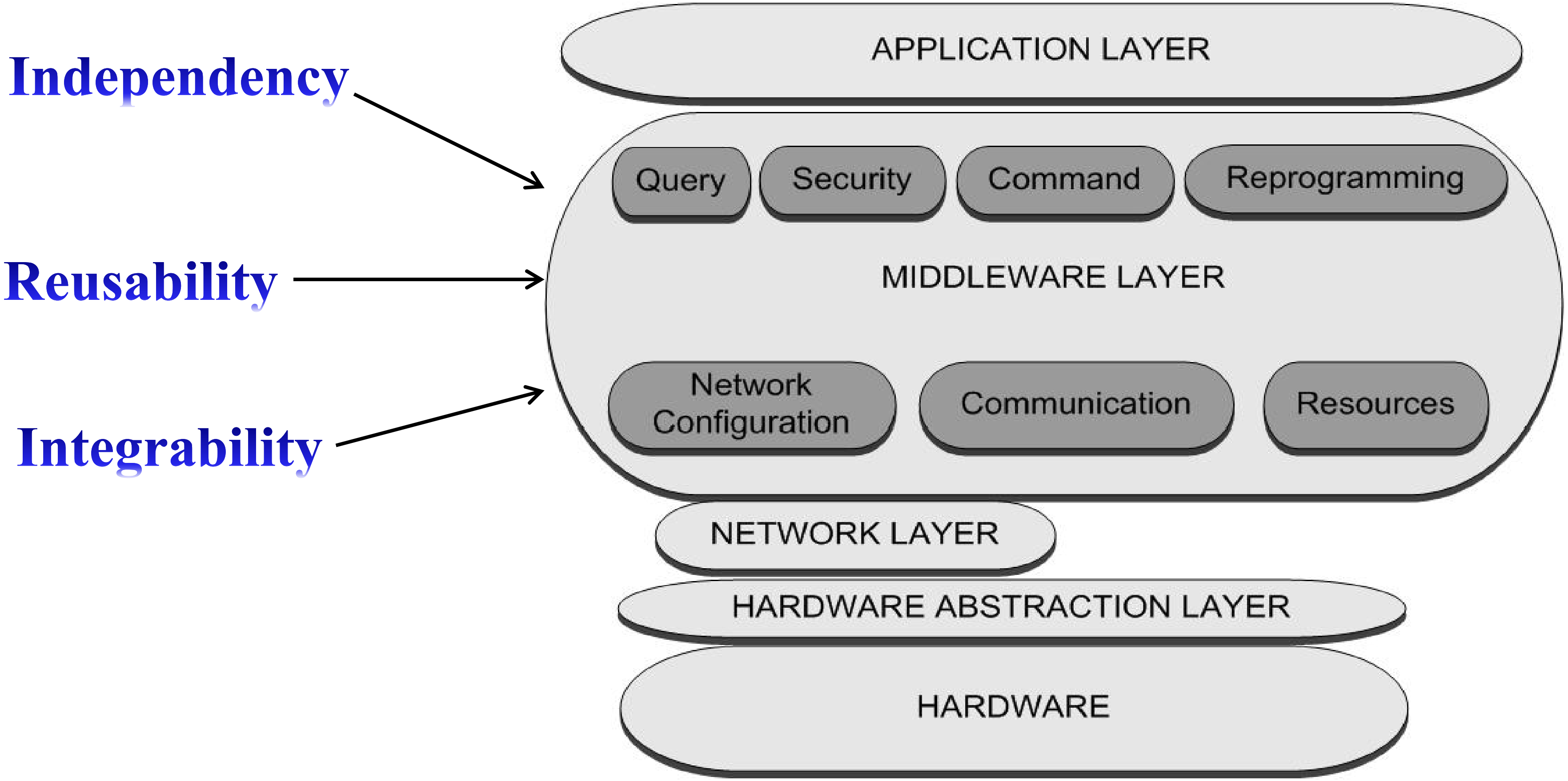
- µSWN Project was working for 3 years from October 2006 to November 2009.
- The µSWN Consortium was composed of 10 partners from different European countries: Spain, France, Greece and Lithuania.

Origin of This Middleware Approach

- µSWN's project main objectives:
  - To research generic and reusable Software-Hardware solutions for WSNs that are common to existent and potential future applications.
  - To research and develop a Middleware architecture enabling a platform for reusable components to ease future developments regarding similar systems under real-time restrictions.
  - To apply WSN technology to three real world scenarios: Surveillance, Multi-tracking and Critical-monitoring.

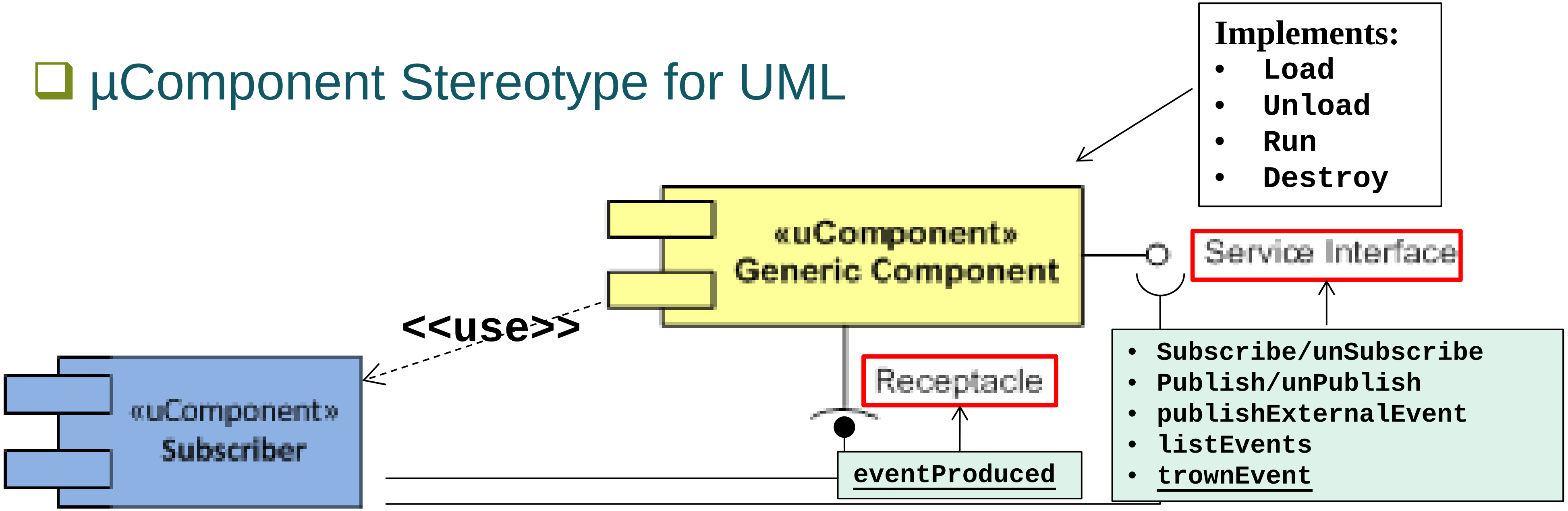
The Middleware Architectural Context

- Architectural Approach



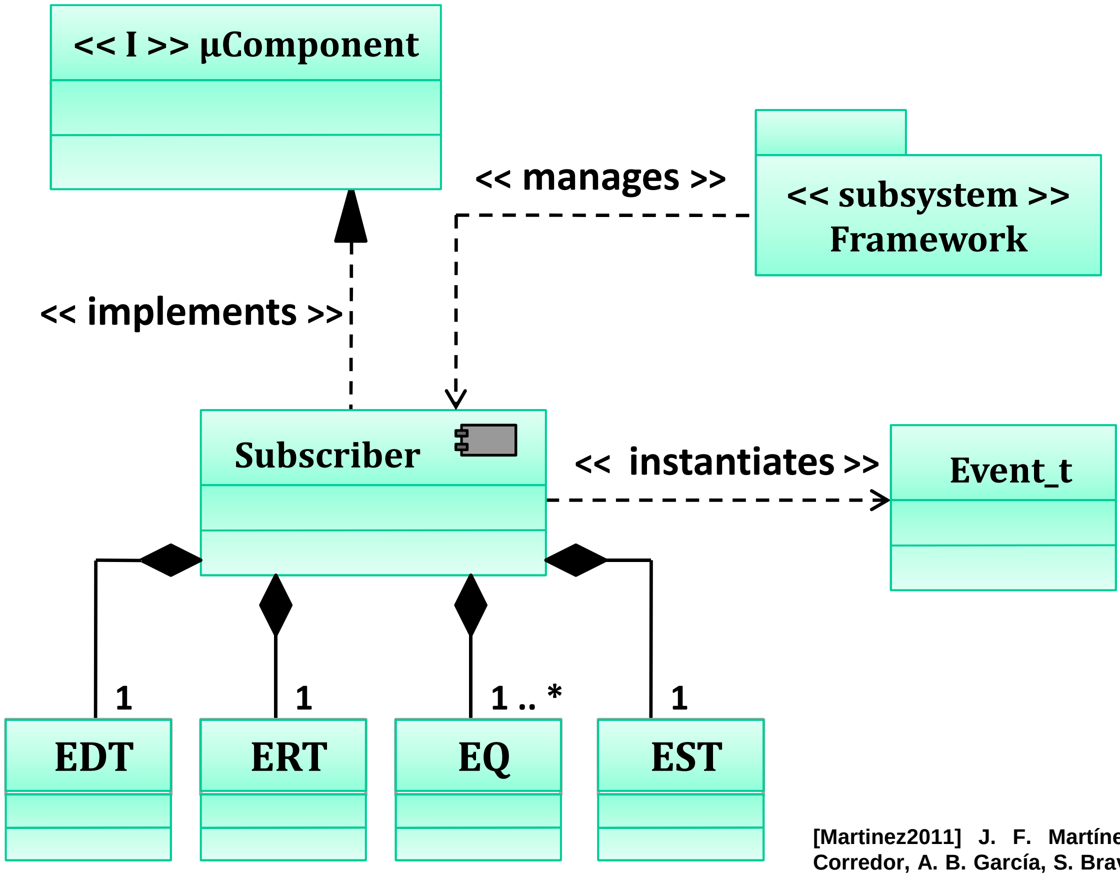
Middleware Components

- µComponent Stereotype for UML



- Communication between receptacles and interfaces can be performed through *events*
  - Basic operations: (Un)*Publications* and (Un)*Subscriptions*
- Two interaction modes: PUSH and PULL.
- Direct calls to component methods can be also enable

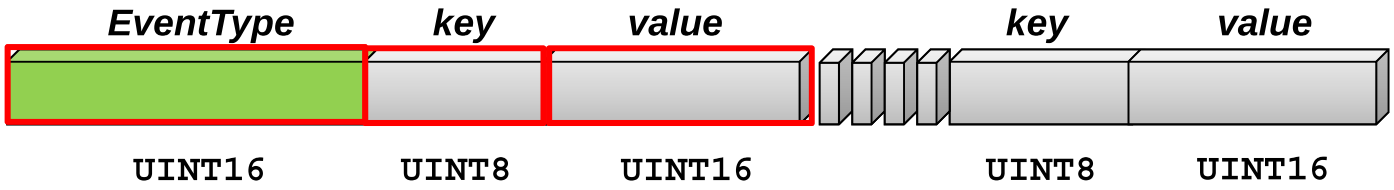
Middleware Kernel



[Martinez2011] J. F. Martínez, M. S. Familiar, I. Corredor, A. B. García, S. Bravo and Lourdes López, "Composition and deployment of e-Health services over Wireless Sensor Networks". Mathematical and Computer Modelling, Elsevier, vol. 53, num. 3-4, pp. 485-503, 2011.

µOpen Distributed Inter-Component Communication Protocol

- Data Unit: Event

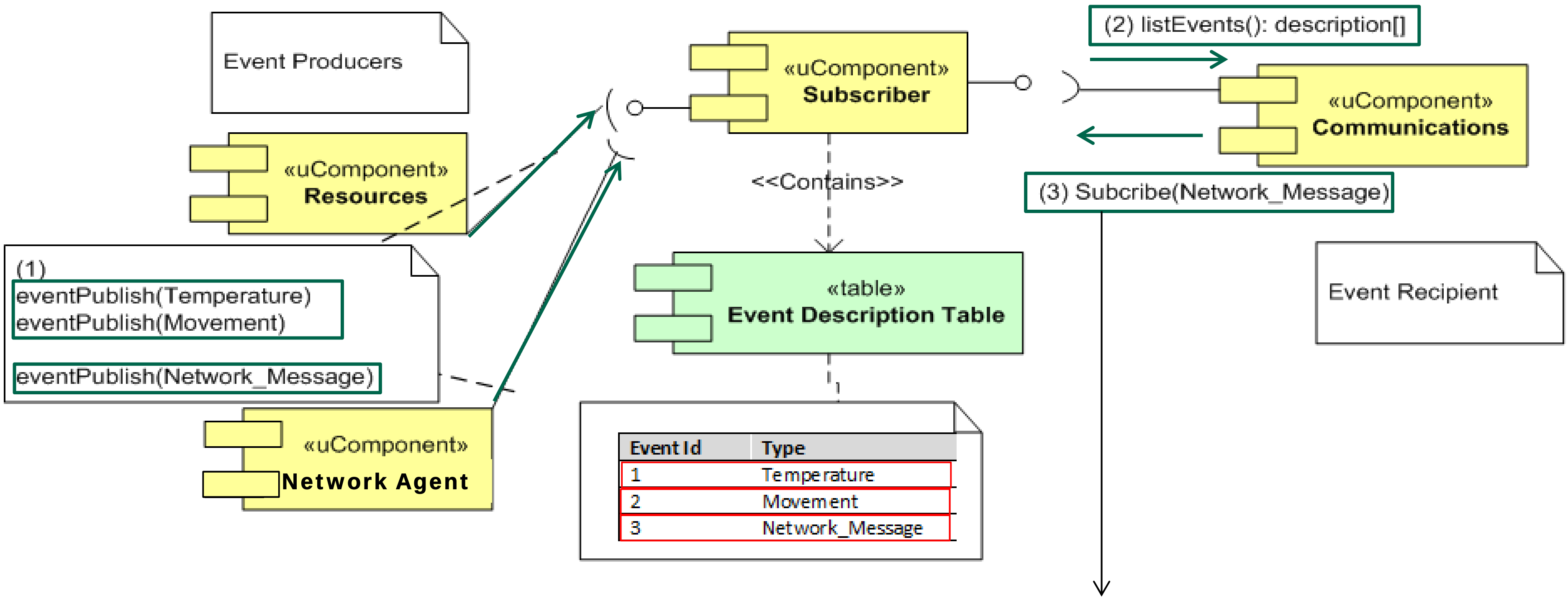


- Event Type: Type of event that will be dispatched.
  - E.g. Temperature Threshold
- key-value pairs: event's useful data.
  - E.g. Celsius-38º; Farenheit-100º

[Martinez2011] J. F. Martínez, M. S. Familiar, I. Corredor, A. B. García, S. Bravo and Lourdes López, "Composition and deployment of e-Health services over Wireless Sensor Networks". Mathematical and Computer Modelling, Elsevier, vol. 53, num. 3-4, pp. 485-503, 2011.

µOpen Distributed Inter-Component Communication Protocol

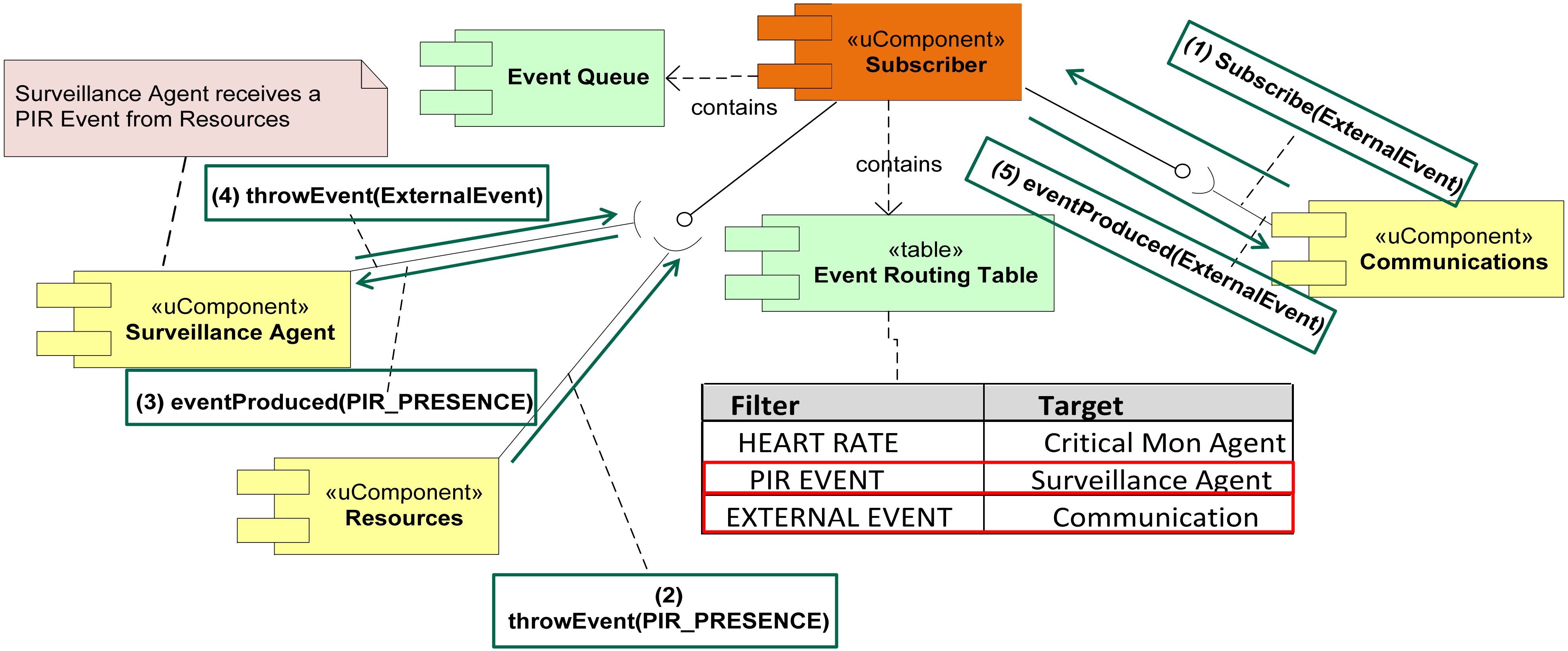
❑ Publications and Subscriptions



- ❑ A Subscription generates an entry in **Event Routing Table**
  - ❍ EventType, ProducerID, ConsumerID and Event Filter

µOpen Distributed Inter-Component Communication Protocol

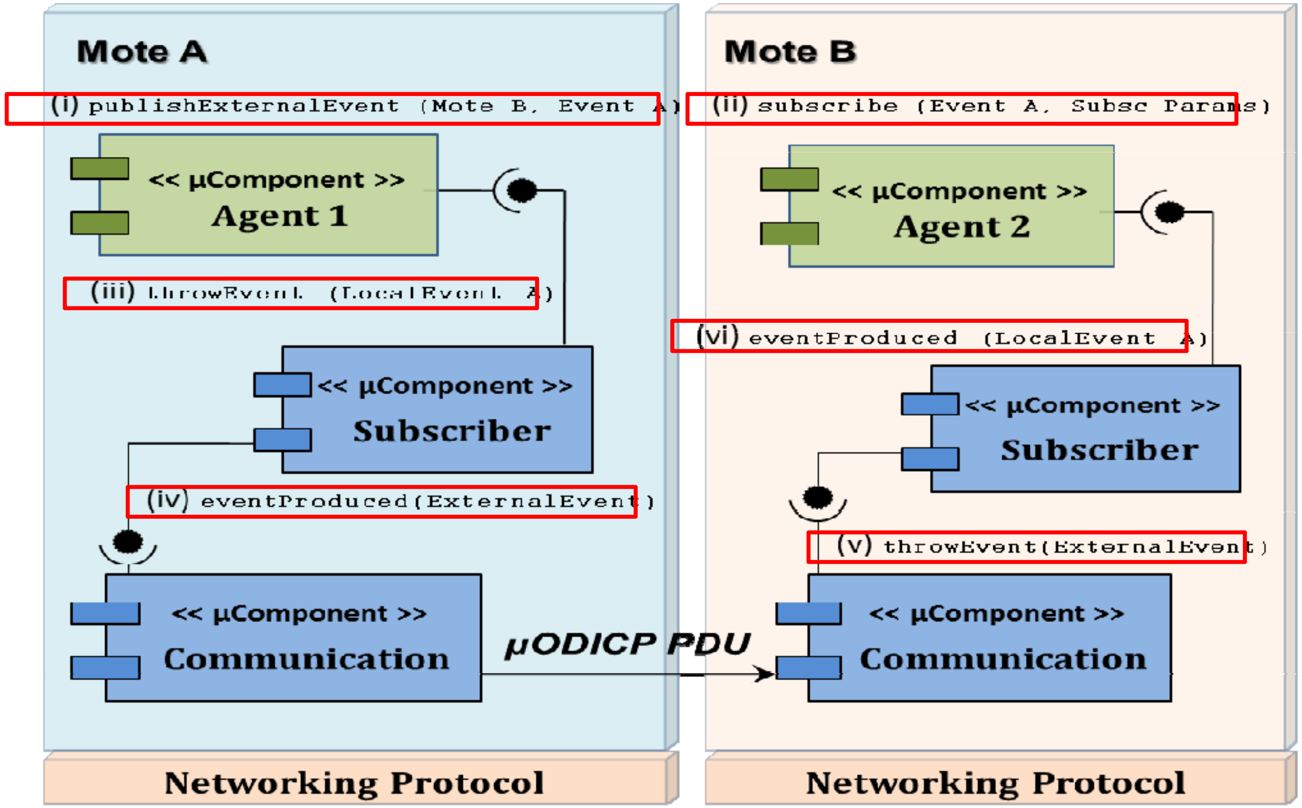
❑ Event dispatching (intra-node)



Filter	Target
HEART RATE	Critical Mon Agent
PIR EVENT	Surveillance Agent
EXTERNAL EVENT	Communication

µOpen Distributed Inter-Component Communication Protocol

❑ Event dispatching (inter-node)



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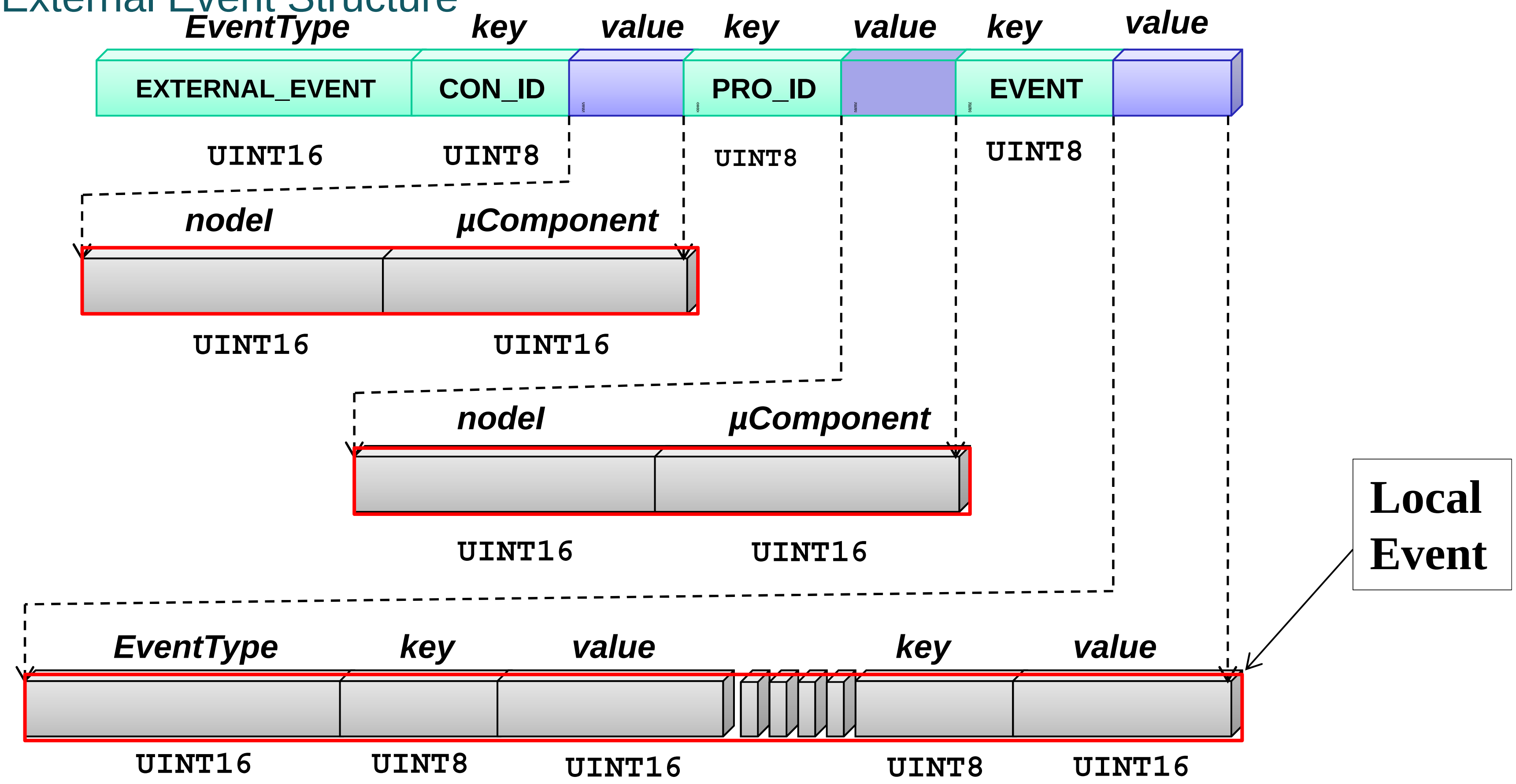
µOpen Distributed Inter-Component Communication Protocol

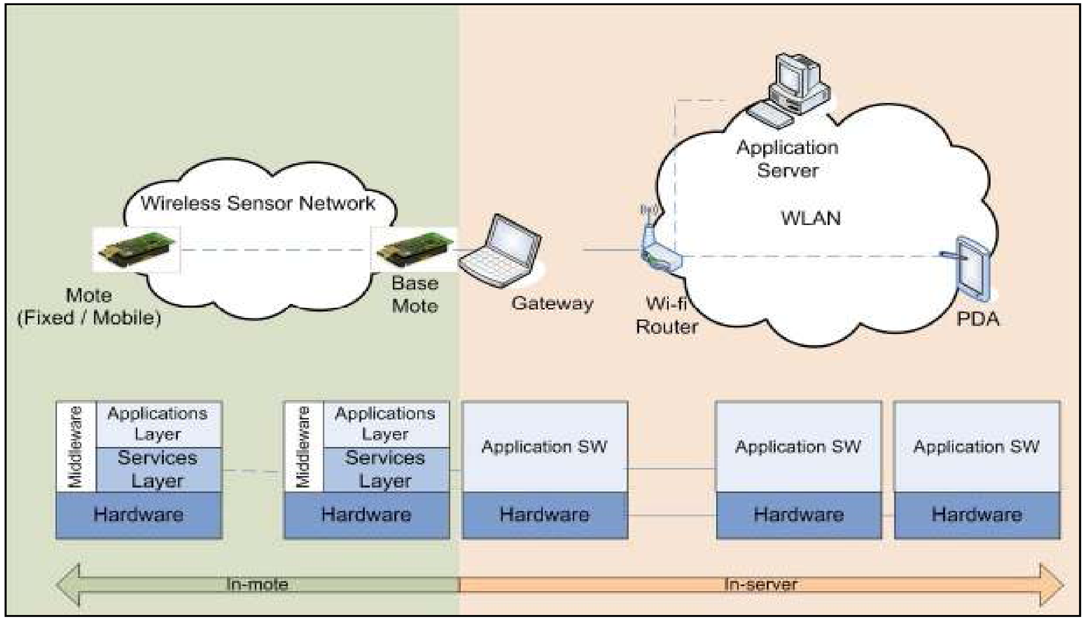
- Event dispatching (inter-node)
  - External Event Structure

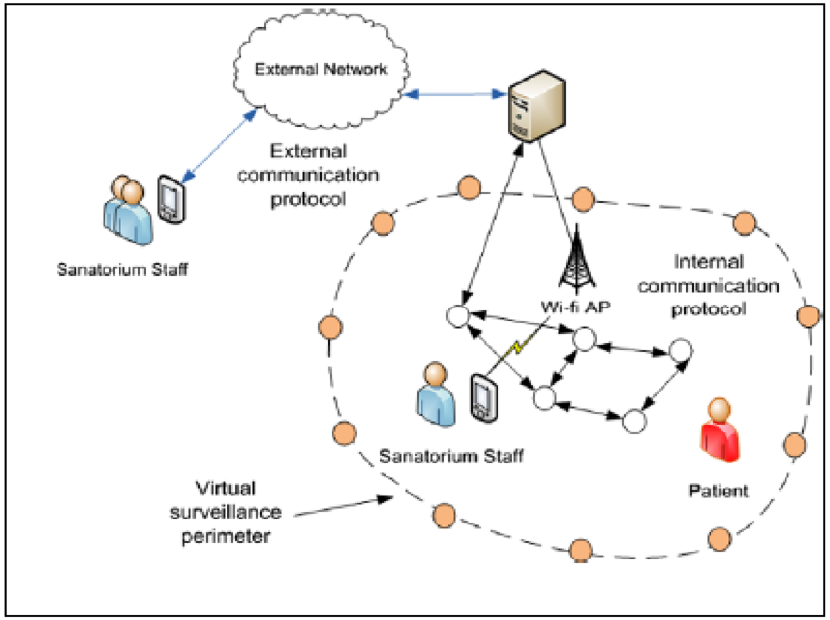


[Martinez2011] J. F. Martínez, M. S. Familiar, I. Corredor, A. B. García, S. Bravo and Lourdes López, “Composition and deployment of e-Health services over Wireless Sensor Networks”. Mathematical and Computer Modelling, Elsevier, vol. 53, num. 3-4, pp. 485-503, 2011.

Validation Scenario

- System deployment at Versme Sanatorium, Birstonas (Lithuania)





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- Three real world validation scenarios
  - Surveillance, Multi-tracking and Critical Monitoring

Validation Scenario

- **Surveillance Scenario**
  - **Objectives**
    - To detect intruders, patients and medical staff crossing a virtual perimeter rounding the Sanatorium
  - **Deployment**
    - Fixed nodes connected to PIRs
    - Bracelet nodes (mobile nodes)

Surveillance Agent

uSWN CAD

[Martinez2011] J. F. Martínez, M. S. Familiar, I. Corredor, A. B. García, S. Bravo and Lourdes López, "Composition and deployment of e-Health services over Wireless Sensor Networks". Mathematical and Computer Modelling, Elsevier, vol. 53, num. 3-4, pp. 485-503, 2011.

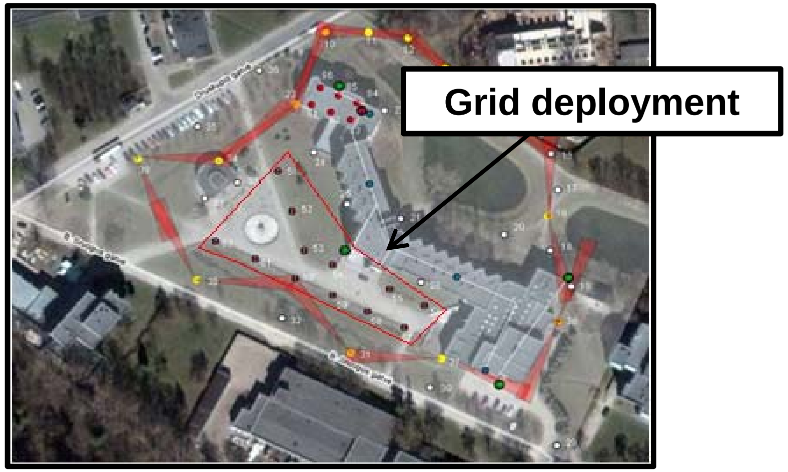
Fixed node with PIRs

[Martínez2010] J. F. Martínez, S. Bravo, A. B. García, I. Corredor, M.S. Familiar, L. Lopez, V. Hernandez and A. Da Silva, "Pervasive surveillance-agent system based on wireless sensor networks: design and deployment", Measurement Science and Technology, vol. 21, num. 12, 2010.

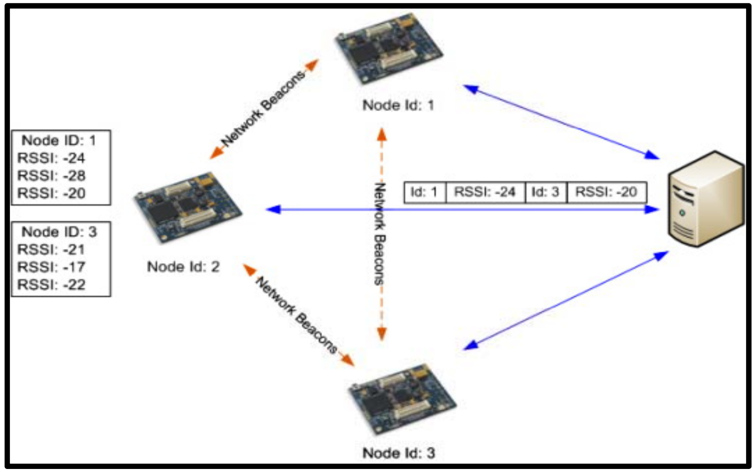
Validation Scenario

- **Multi-tracking scenario**
  - **Objectives**
    - To track patients wearing bracelet nodes
  - **Deployment**
    - Grid of fixed nodes (beacons)
    - Bracelet nodes (mobile nodes)

} **Multi-tracking Agent**



Multi-tracking operation



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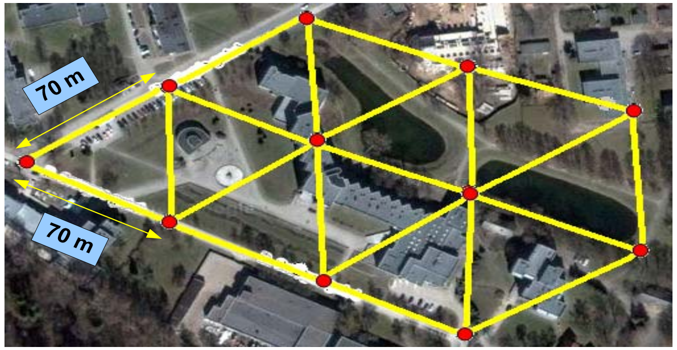
Validation Scenario

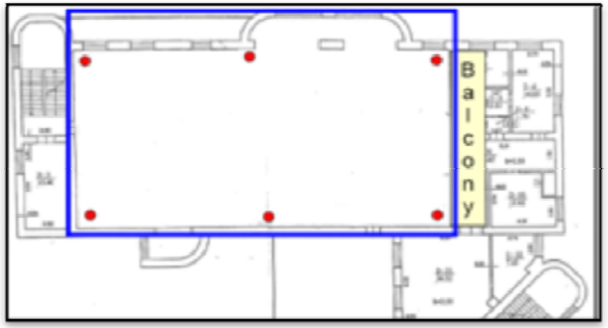
- Critical Monitoring Scenario
  - Objectives
    - To monitor vital signs of patients (heart rate and body temperature)
    - To monitor environmental parameters (temperature and humidity)
  - Deployment
    - Fixed nodes (out-door and in-door deployment)
    - Bracelet nodes (mobile nodes) with biomedical sensors

} Critical Monitoring Agent

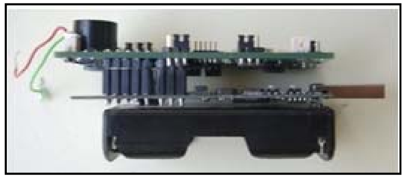
Out-door deployment



In-door deployment



Bracelet node



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More WSN resources. **http://www.diatel.upm.es/jfmartin/jfmartin_ENG.html**