



University of Pavia

Faculty of Engineering

Master Degree in Computer Engineering

WSN-BASED ENVIRONMENT MONITORING SYSTEM



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Master Degree thesis of
Filippo De Stefani

OBJECTIVE



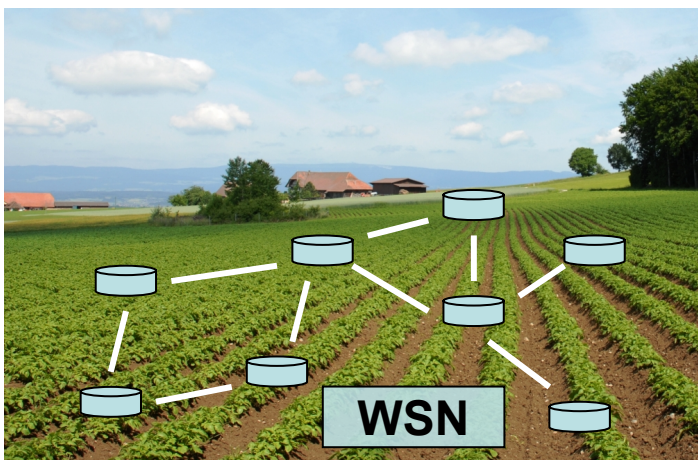
OBJECTIVE:

Realization of an environment monitoring system:

- out-of-the-box
- cheap
- expandable
- versatile
- open source

PHASES:

- 1) WSN design
- 2) Design of storage, querying and analysis system
- 3) Test (radio propagation, system performances)

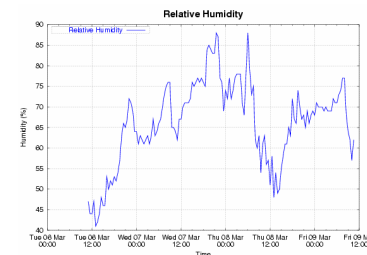


DB SERVER

USER



WEB SERVER



OBJECTIVE

WSN INTRODUCTION

WSN DESIGN

SYSTEM DESIGN

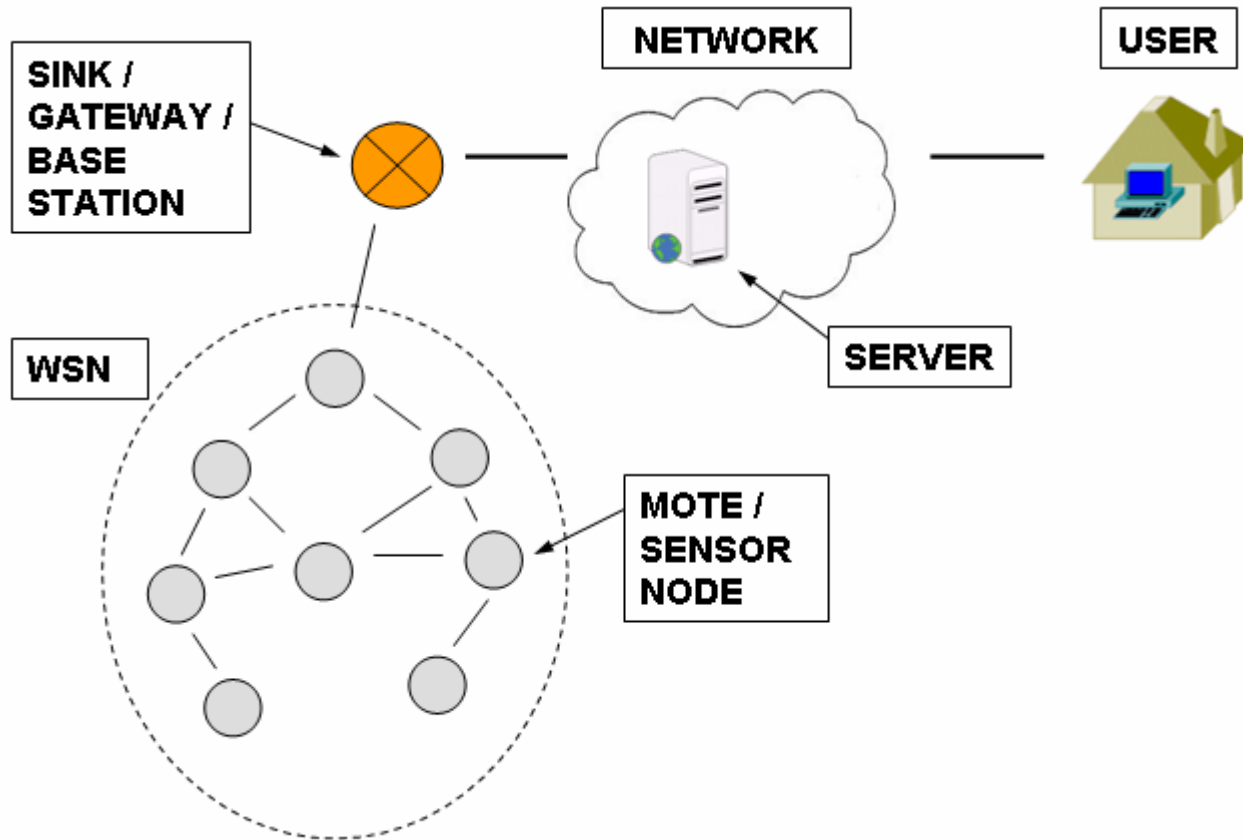
TEST



WHAT IS A WSN?



A **WSN (Wireless Sensor Network)** is a wireless network composed by elements which are able to make measurements, elaborate and send them to a sink point



OBJECTIVE

WSN INTRODUCTION

WSN DESIGN

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TEST



CHALLENGES OF A WSN



CHALLENGES OF A WSN:

- LIMITED ENERGY
- DYNAMIC NETWORK TOPOLOGY
- LARGE SCALE
- COMMUNICATION PROBLEMS
- HOSTILE ENVIRONMENT CONDITIONS



REQUIRED MECHANISMS:

- ENERGY-EFFICIENT OPERATIONS
- MULTI-HOP CONNECTIONS
- SELF-CONFIGURING NETWORK

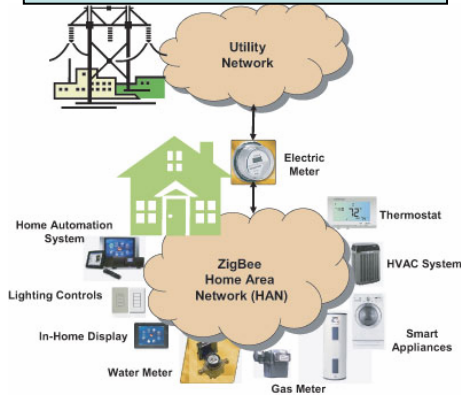


POSSIBLE APPLICATIONS



DOMESTIC:

- Home Automation
- Smart Metering



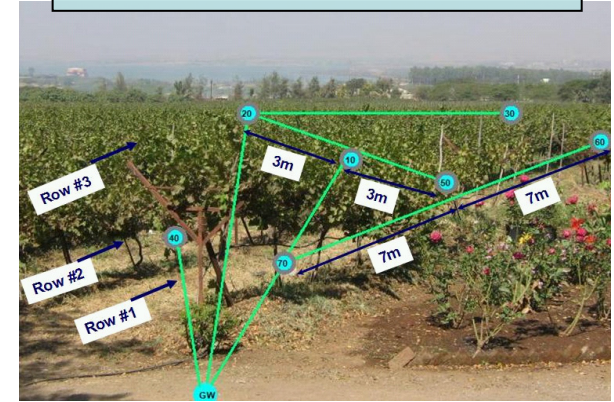
INDUSTRIAL:

- Automation
- Supply Chain



ENVIRONMENTAL:

- Precision agriculture
- Monitoring



MILITARY:

- Surveillance
- Targets Tracking



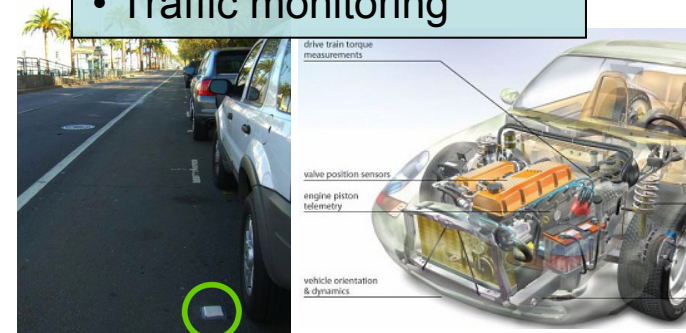
BIOMEDIC:

- Biological data monitoring



TRANSPORTS:

- Intra-vehicle sensors
- Traffic monitoring



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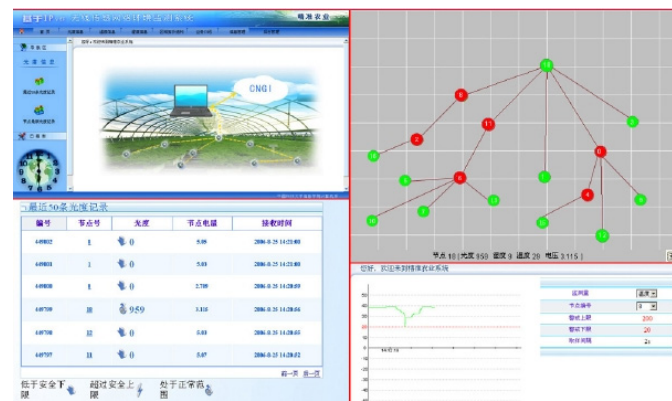
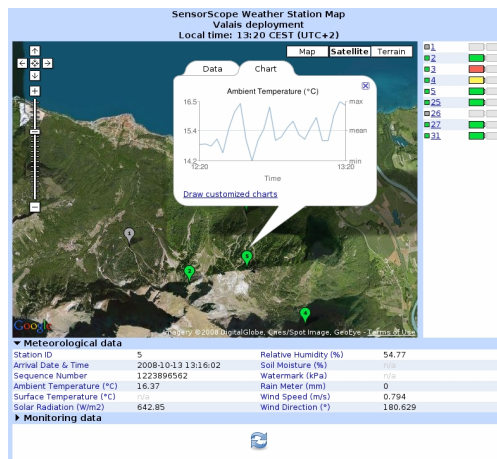
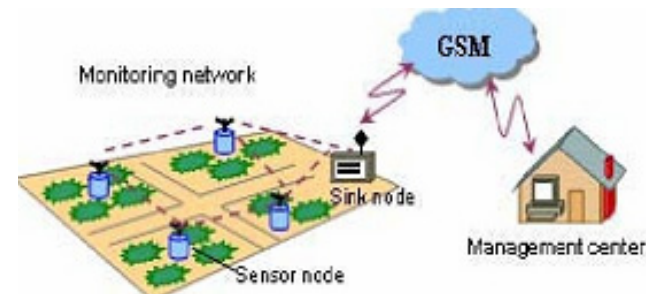
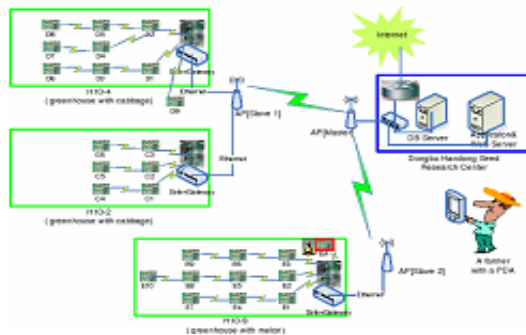
AVAILABLE MONITORING SOLUTIONS



Environment monitoring solutions are already available

The realized project is different because of:

- **LOW COST**
- **COMPLETENESS**
- **HARDWARE** of deployed nodes



OBJECTIVE

WSN INTRODUCTION

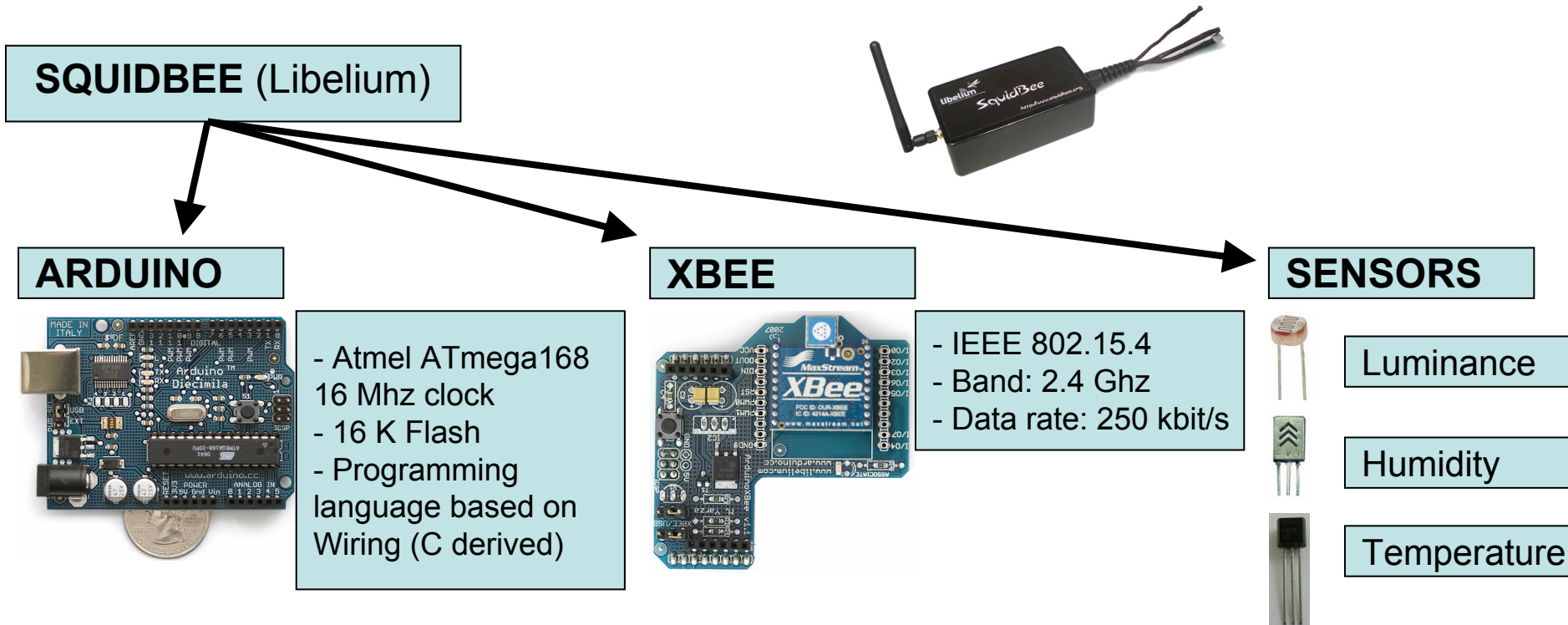
WSN DESIGN

SYSTEM DESIGN

TEST



DEPLOYED NODES



PRO	CON
COST (120 €)	CONSUMPTIONS
SIMPLICITY	MEMORY

WSN FUNCTIONALITIES



DEVELOPED FUNCTIONALITIES:

- DUTY-CYCLING
- POWER MANAGEMENT
- ROUTING

FUNCTIONALITIES ALREADY IMPLEMENTED:

- BIT TRANSMISSION
- MEDIUM ACCESS CONTROL



POWER MANAGEMENT



SCHEDULED RENDEZVOUS SLEEP / WAKEUP protocol

Scheduling composed by 3 phases:

SAFETY → activation

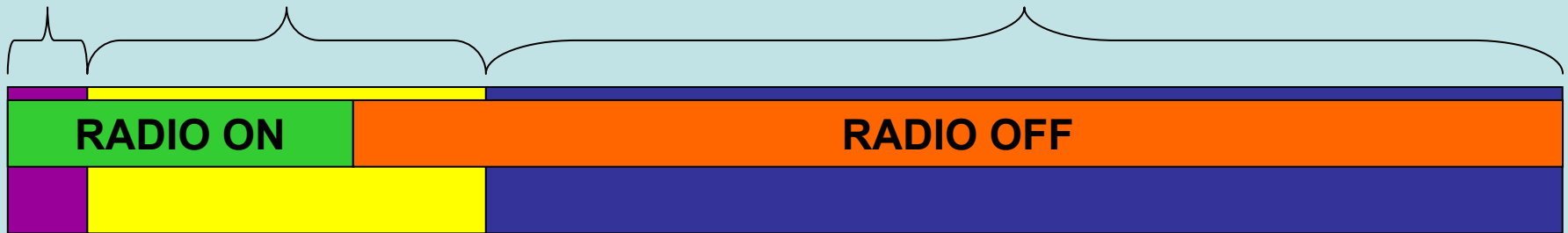
ACTIVE → packet transmission and receive

SLEEP → stand-by

SAFETY

ACTIVE

SLEEP



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ROUTING



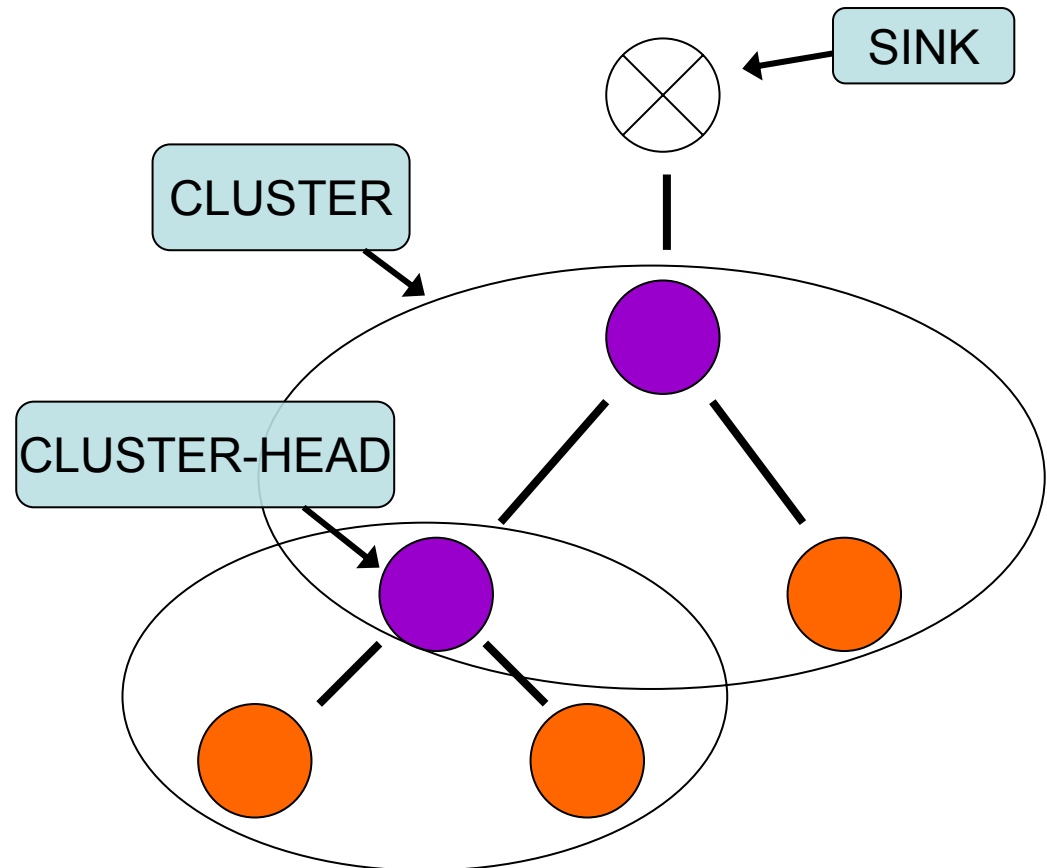
REACTIVE HIERARCHICAL ROUTING

HIERARCHICAL :

Hierarchical structure, clusters split, managed by cluster-heads

REACTIVE:

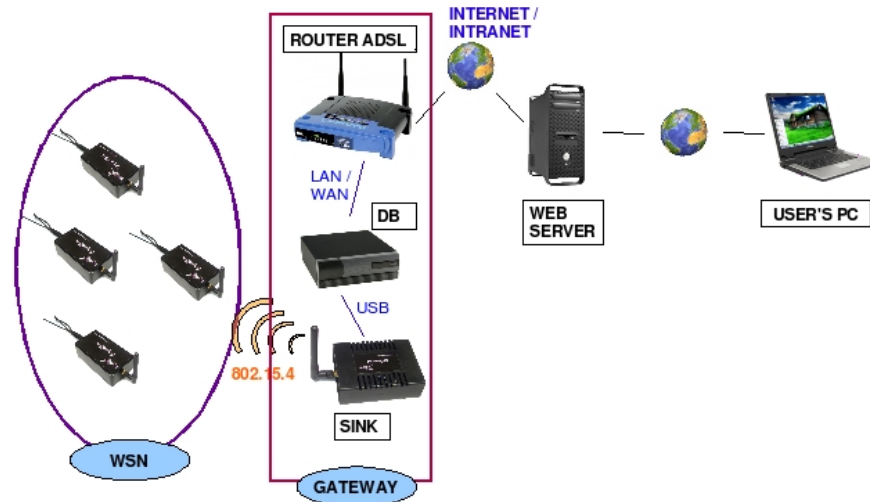
- Every node contains its cluster-head address only
- In case of forward path messages (from root to leaves), cluster-heads learn routes on-demand



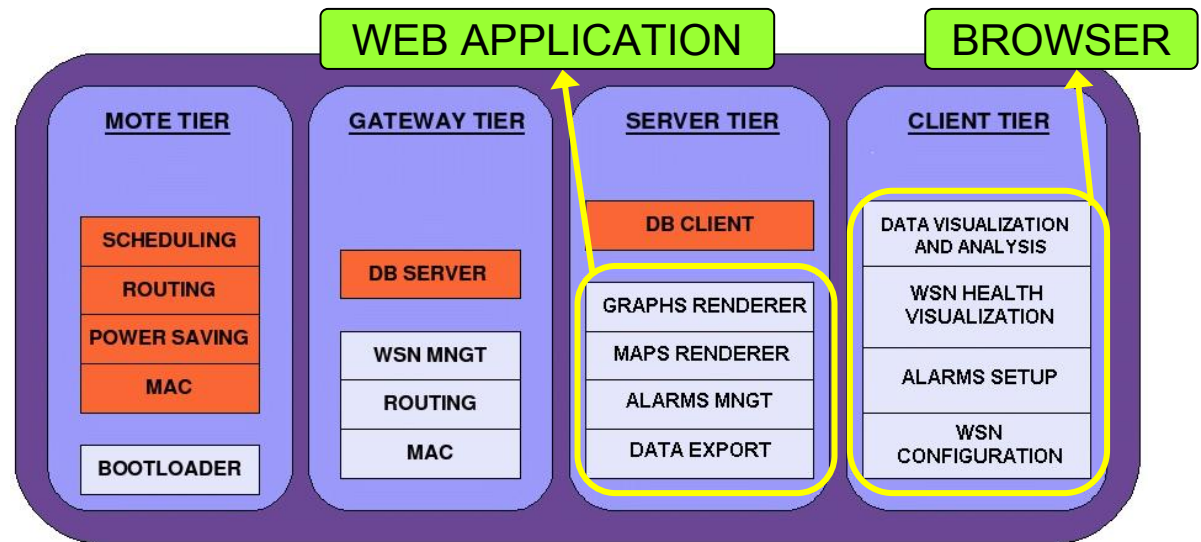
STORAGE AND QUERYING SYSTEM



HARDWARE ARCHITECTURE



SOFTWARE ARCHITECTURE



OBJECTIVE | WSN INTRODUCTION | WSN DESIGN | SYSTEM DESIGN | TEST



WEB APPLICATION (1/4)



MONITORING

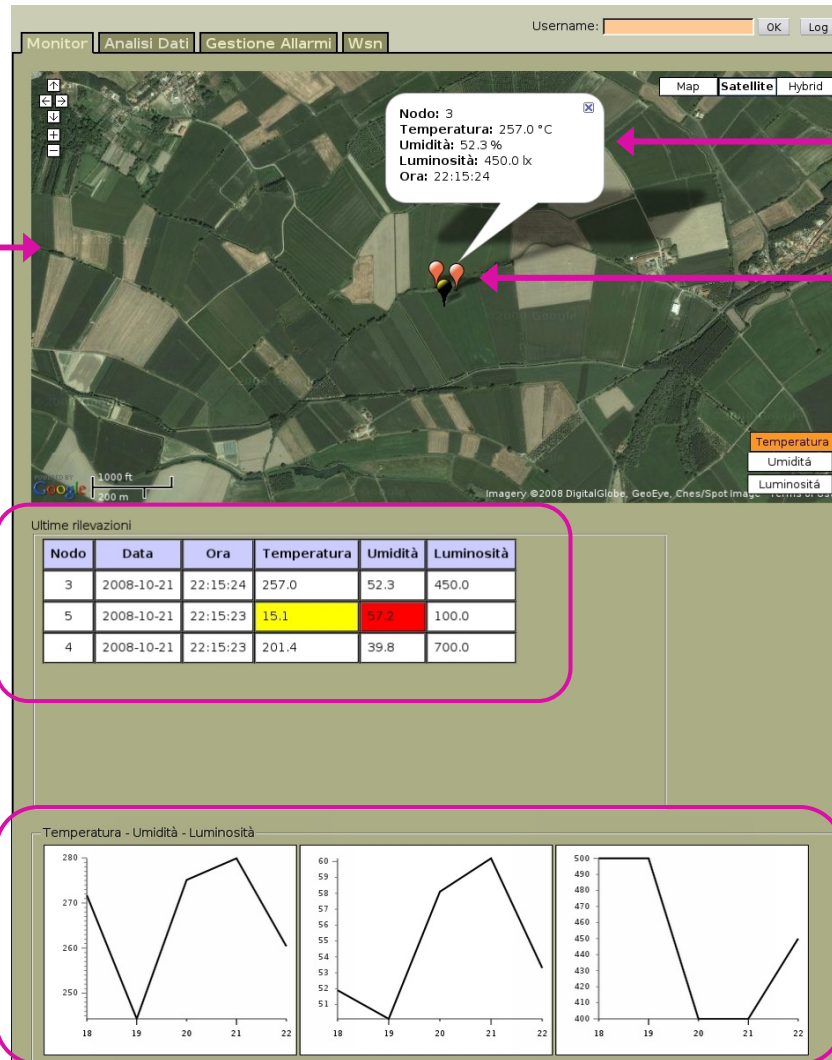
MAP

LAST MEASUREMENT

NODES

LAST MEASUREMENTS

24H GRAPHS



OBJECTIVE

WSN INTRODUCTION

WSN DESIGN

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WEB APPLICATION (2/4)



DATA ANALYSIS

DATA
QUERY
FORM

Monitor | Analisi Dati | Gestione Allarmi | Wsn

Richiesta dati

Temperatura Umidità Luminosità

Giorno: (gg/mm/aaaa)

Nodo:

Genera foglio di calcolo

Ok

Temperatura - Umidità - Luminosità

31
30
29

19:50 20:50 22:10

REQUESTED
GRAPHS

OBJECTIVE

WSN INTRODUCTION

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WEB APPLICATION (3/4)



ALARMS SETUP

ALARM AREA

REGISTERED USERS

ALARM AREA CONFIGURATION

Monitor | Analisi Dati | Gestione Allarmi | Wsn

Username: OK Log out

Temp 1 > 3 Temp 2 >

Umid 1 < 2 Umid 2 > 90

Lum 2 > Lum 2 >

Owner Pacman

Rimuovi allarme temperatura
 Rimuovi allarme umidità
 Rimuovi allarme luminosità
 Rimuovi area di allarme

Salva

Utenti registrati

USER	EMAIL	
luno		Salva
r		Salva
l		Salva

Uttime rilevazioni

Nodo	Data	Ora	Temperatura	Umidità	Luminosità
3	2008-10-21	23:05:24	264.3	54.5	450.0
5	2008-10-21	23:05:23	15.1	57.9	100.0
4	2008-10-21	23:05:23	195.1	37.5	750.0

Temperatura - Umidità - Luminosità (ultime 24h)

OBJECTIVE

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WEB APPLICATION (4/4)



WSN HEALTH
VISUALIZATION

NODE
CONNECTION DATA

WSN

Monitor | Analisi Dati | Gestione Allarmi | Wsn

Serial Low: 4000F2DC
MY addr. nodo: 3
MY addr. padre: 1
Stato: active
Data ingresso: 2008-10-21
Ora ingresso: 18:40:04

Map | Satellite | Hybrid

1000 ft
200 m

Imagery ©2008 DigitalGlobe, GeoEye, Cnes/Spot Image - Terms of Use

Impostazioni
Intervallo trasmissione dati (in secondi,min = 1): Indirizzo IP database:

Nodi senza coordinate

Serial Low: Latitudine: Longitudine:

Serial Low: Latitudine: Longitudine:

OBJECTIVE

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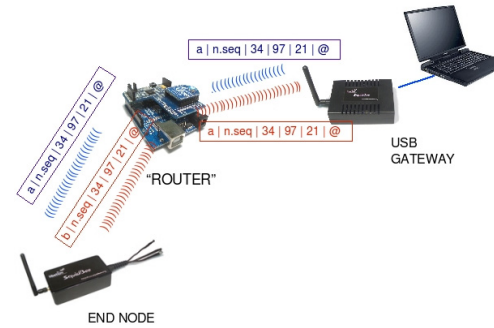
TEST



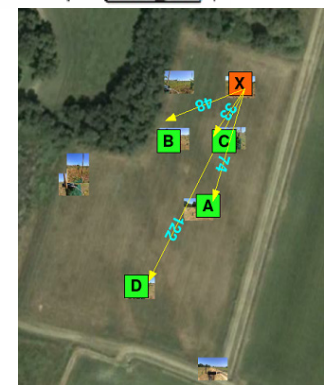
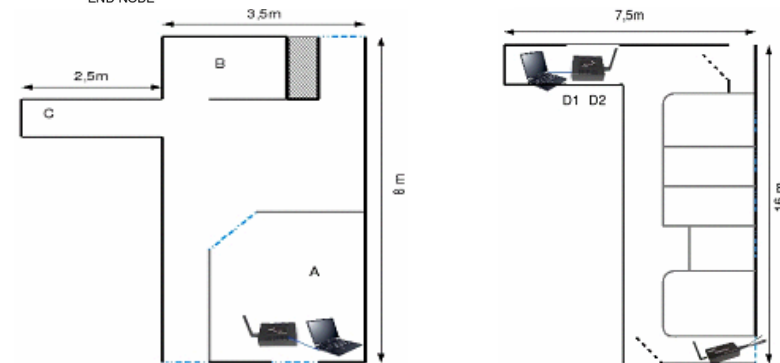
TEST



1) RADIO PROPAGATION ANALYSIS



2) COMPLETE SYSTEM TEST

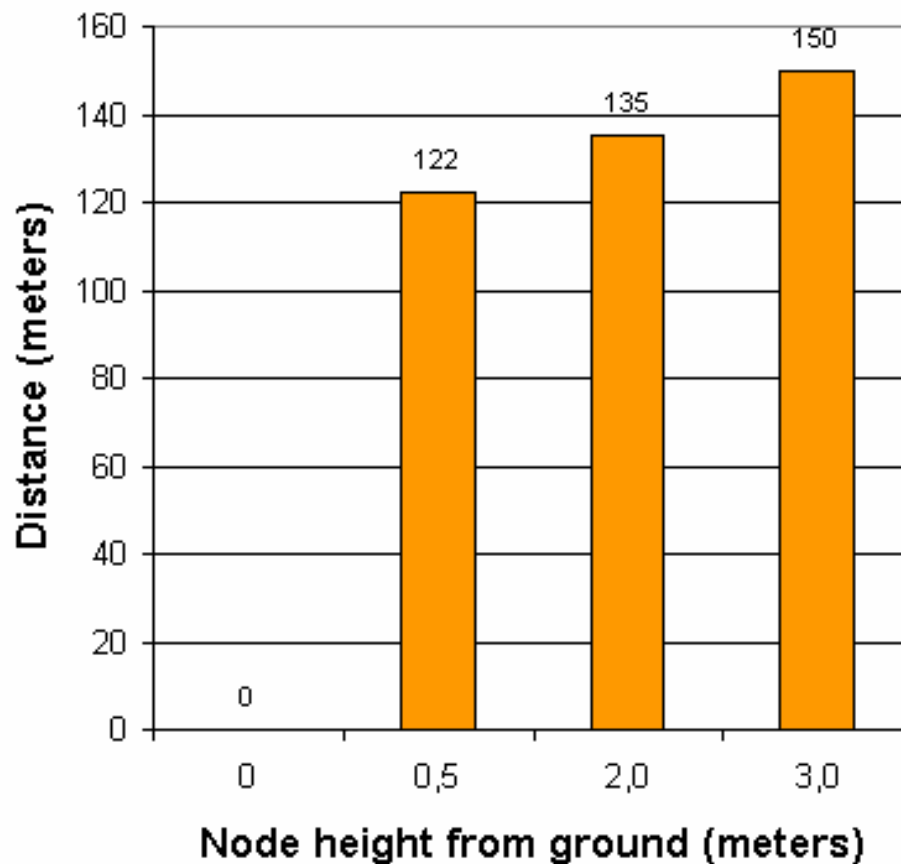


RADIO PROPAGATION ANALYSIS



DO NOT PLACE
NODES ON THE
GROUND!

Max distance between nodes



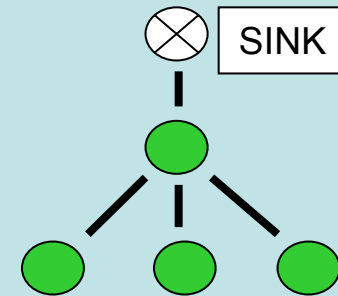
COMPLETE SYSTEM TEST



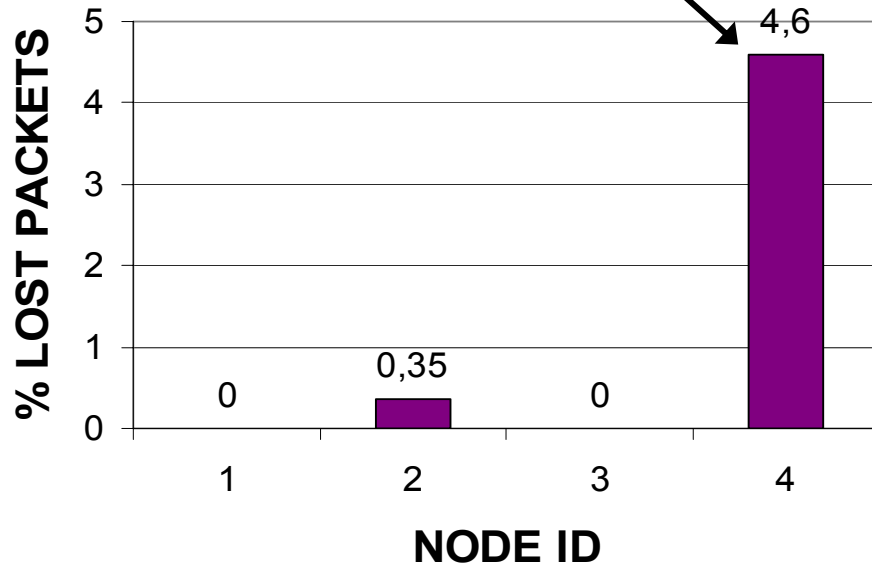
SETUP

- 4 nodes indoor deployment
- 1 minute transmission interval

WSN STRUCTURE



Farthest and integrated antenna node



LIFETIME

- After 4 hours and 41 minutes: batteries (150 mAh) not depleted

A few days lifetime if:

- 2500 mAh batteries
- Power saving of MCU
- Longer transmission interval



CONCLUSIONS



- The system works correctly and has good performances

- Improvable aspects



- IMPLEMENT SECURITY
→ WSN, client-server communications, web application
- IMPLEMENT MCU POWER SAVING MECHANISM
- ADD INTERFACE FUNCTIONALITIES
- IMPROVE MULTI-USER MANAGEMENT





END

THANK YOU FOR YOUR ATTENTION

