DEVELOPMENT OF A WIRELESS SENSOR NETWORK FOR STRUCTURAL HEALTH MONITORING

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**Introduction: wireless sensor networks**

## Wireless Networks

### Advantages
- Costs
- Mobility
- Flexibility

### Disadvantages
- Battery Consumption
- Reliability
- Security

## A Wireless Sensor Network:

Consists of a large number of nodes:
- Deployed in the environment
- Equipped with sensors
- Provisioned with short-range wireless communication capabilities
- Battery-powered
Types of motes and WSNs' topology

**TYPES OF MOTES**
- Mote – gateway
- Mote – sensor

**TOPOLOGY OF WSNs**
- Star
- Mesh
- Tree
Introduction: uses of WSN

APPLICATIONS:

- Monitoring
- Supervision
- Control

SHM
(Structural Health Monitoring)

- Measurement of vibrations
- Experiments in the world
**EUVENTRE**
*(NON-PROFIT FOUNDATION)*

- Applied research in the field of seismic engineering
- Simulations on real buildings
- Analytical models

**W-TREMORS**

Platform was engineered and implemented:
- Ex-novo
- Alternative to existing wired system
- Wireless Tremors vibRation and Earthquakes MonitoRing
Introduction: models and standard motes

TYPES OF HW
• Motes with integrated sensors.
• Motes that use a small O.S. etc...

THE PLATFORM SQUIDBEE
• Arduino board with ATMega168 processor.
• Radio XBee of DiGi.
• SquidBee: is a platform that is not designed for SHM.
• Sensor used is a Kistler's accelerometer.

COMUNICATION PROTOCOL 802.15.4
• Physical layer
• MAC layer
W-TREMORS: restraints and requirements

REQUIREMENTS OF THE PLATFORM

• Synchronization
• Absence of collisions
• Real-Time
• Certainty on sender's ID

CONSTRAINS OF THE PLATFORM

• Mono-task
• CSMA/CA at MAC layer
• Transmission's time
• Maximum resolution is ms
W-TREMORS: synchronization

SYNCHRONIZATION

• Managing latency errors of each motes

• Managing synchronization of the whole platform.

LATENCY ERROR

• Send-time

• Access-time

• Propagation-time

• Receive-time
W-TREMORS: drift

- Changes of physical clock.
- Drift – Rate: measurement unit.

Drift – Rate: $83 \times 10^{-6} \sim 1$ ms every $12$ s

Drift – Rate: $1,67 \times 10^{-6} \sim 1$ ms every $10$ m
SYNCHRONIZATION ALGORITHMS FOR WSN

- RBS (Reference Broadcast Synchronization)
- TPSN (Timing-sync Protocol for Sensor Network)
- FTPS (Flooding Time Synchronization Protocol)
- ...

ALGORITHMS USED FOR W-TREMORS

- Star typology
- RBS
- Without reference (is single – hop!)
- Motes wait broadcasting signal
W-TREMORS: TDMA e Bursts

TDMA BUILT AT THE APPLICATION LAYER

- Define transmissions' time-slot for each motes.
- Schedule the use of the channel.
- Reduces collisions.

PROBLEM

- Displacement due to drifts results in:
  - Delays of transmissions
  - Unrecognizable packages.

SOLUTION

- Build an application-layer PDU including the ID of the mote
- Bursts: insert two or more measurements in a single PDU

Remote Sensing Group
W-TREMORS: Bursts

ADVANTAGES

- Less PDU sent by each node
- More motes are allowed inside the sensor network

\[
F_{c_{\text{max}}} = \frac{C_{\text{canale}}}{(P_{\text{header}} + N + P_{\text{tailer}})}
\]

\[
N_{\text{max}} = \left\lfloor \frac{C_{\text{canale}}}{F_c} - 7 \right\rfloor
\]
Setup phase: sample Gateway – Sensor communication

**Gateway**
- Send "Name (1) of Motes"
- Response "OK"
- Send setting "Burst & Offset"
- Response "OK"
- Send setting "Frequency"
- Response "OK"
- Attend "Start..."

**MOTE #1**
- Send "Name (N) of Motes"
- Response "OK"
- Send setting "Burst & Offset"
- Response "OK"
- Send setting "Frequency"
- Response "OK"
- Attend "Start..."
- Send "Start to Acquisition"
W-TREMORS: test at EUCENTRE
W-TREMORS: test at TLC lab (Mantova)

INTRODUCTION

W-TREMORS

CONCLUSION
Conclusion: considerations

- Need to add a guard band at high frequencies.

- Developed code is modular and open source
Conclusions: future developments

• DataBase: improve and speed-up data extraction.

• Remote reset of node (now this is a missing feature)

• Engineering an external case for sensor nodes.
The End