A Fire detection Application on Sensimesh Wireless Sensors Network

Summer school on Wireless Sensor Networks and Smart Objects

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Dagstuhl 8 settembre 2005

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Università degli Studi del Sannio in Benevento

- **The University of Sannio in Benevento is a young University active since 1990 with schools of *Engineering*, *Economics*, *Management, Natural Sciences***
- **The School of Engineering has more than 1600 students; the Department of Engineering has a faculty of 52 people covering the areas of *EE&CS*, *Industrial Engineering* and *Civil Engineering,* and 5 administratives**

- Among others, it offers degrees on *Computer and Systems Engineering* and a graduate course on *Control Engineering* (started in September 2003)

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Goals

- To develop a non-invasive tool for monitoring and controlling of confined environment in home security context;
- To develop a reliable and strong anti-Fire detection “intelligence”;
- To collect data from sensors deployed in a confined environment and apply actions notifying specific events;
- To record data for a future modelling of dynamics and behavior of environmental parameters in confined rooms.

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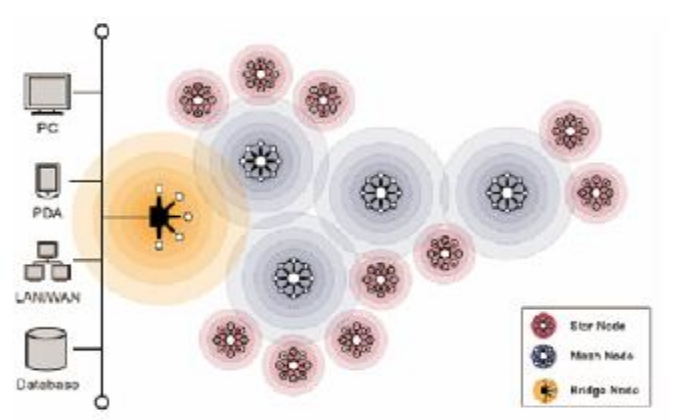
Sensors network

- Sensimesh H900 sensors Network



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Network specification

	BRIDGE	MESH	STAR	EMS
Battery Energy	✓	✓	✓	✓
External Energy	✓	✓		
HeartBeat remote setup		✓	✓	✓
DC IN	✓	✓		
Serial Jack	✓	✓		
Screw Terminal "A"	✓ *	✓ *	✓ **	✓
Screw Terminal "B"	✓ *	✓ *	✓ **	✓
OUT				✓
IN AUX				✓
Buzzer			✓	✓
Bi-directional communication	✓	✓	✓	✓
Algorithm for network Management	✓	✓		
Link to BRIDGE		✓		

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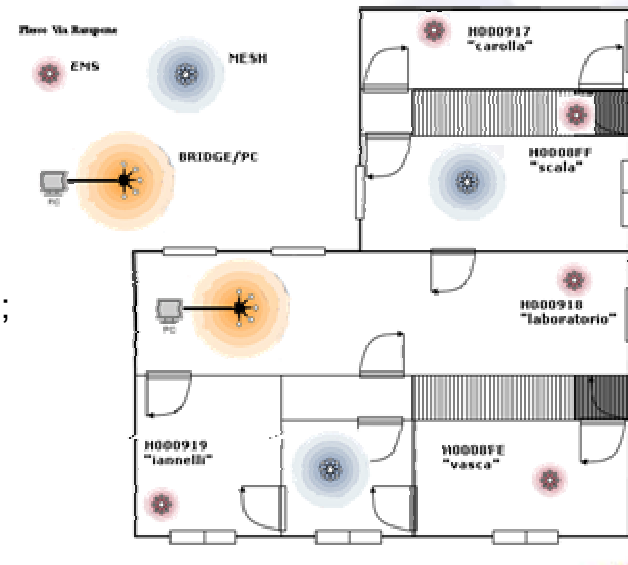
Environment & design space

- Manual one-time deployement;
- Immobile;
- Match box resource;
- Radio H900 comm. modality;
- Gateway and bridge ad hoc infrastructure;
- Battery-powered sensors nodes;
- Net size : 8 nodes;
- Multihop topology network;
- Real Time Event driven Allarm information Qos;



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Limits and constraints

- In this application:
  - Range < ~100 m;
  - Disabled output ports in “ready to install kit” (no actuation is possible);
  - Non real time set up of node parameters;

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Anti-Fire Node

- A smoke sensor connected on a star node port;
- A EMS node to read temperature and humidity;

EMS node

Smoke sensor

STAR node

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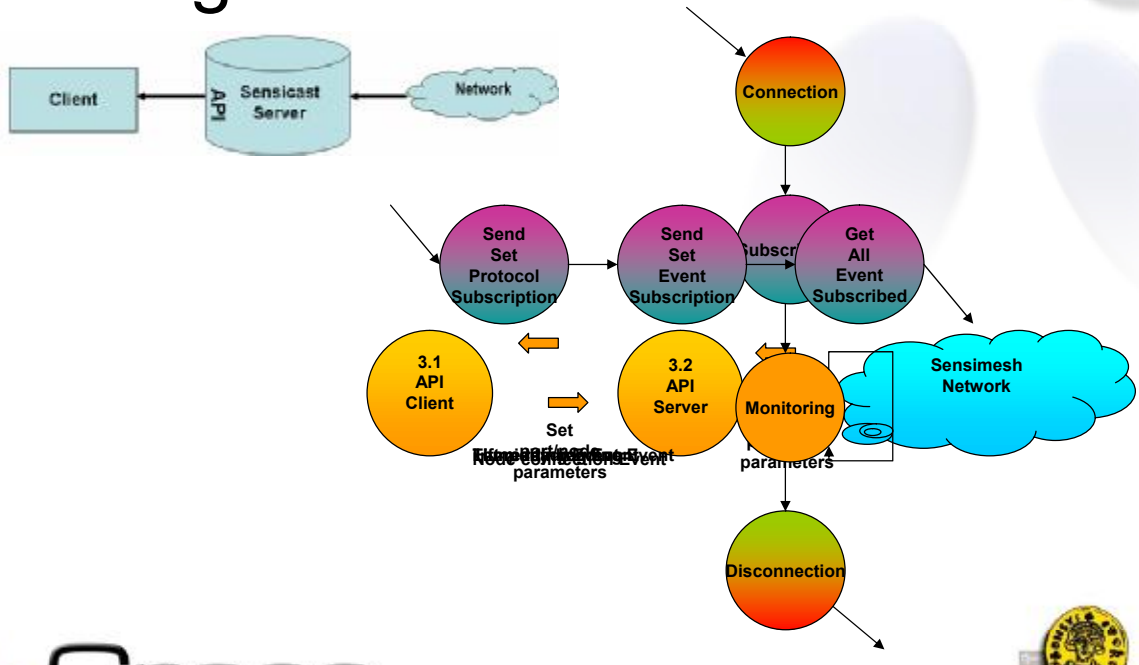
Using a Sensimesh Network



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Fire-Temperature graph

$\theta_g = 1235(1 - 0.324e^{-0.2t^*} - 0.204e^{-1.7t^*} - 0.472e^{-19t^*})$

θ_g [°C] compartment air temperature

t [hour] time

t* [hour] $= t\Gamma$

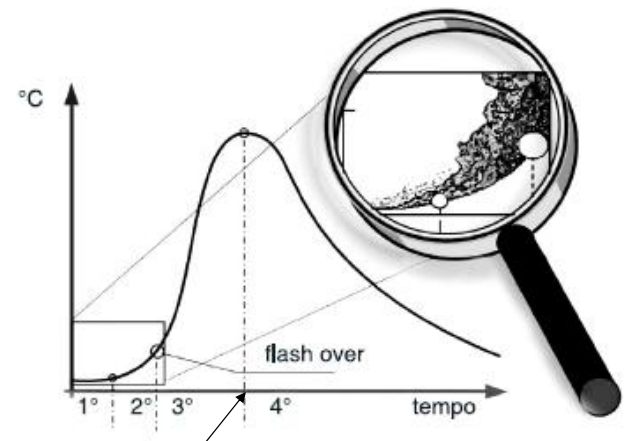
$$\Gamma[\,] = \frac{\left(\frac{O}{b}\right)^2}{\left(\frac{0{,}04}{1160}\right)^2}$$

b [$J/m^2 s^{1/2} K$] $= (\rho c \lambda)^{1/2}$ (variable from 1000 to 2000)

ρ [kg/m^3] room walls density

c [J/kg K] specific heat of room walls

λ [W/m K] termic conductibility of room walls



$$t_d^* \text{ [hour]} = \left(\frac{0{,}13 \cdot 10^{-3}\, q_{t,d} \cdot \Gamma}{O}\right)$$

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Fire simulation parameters setup

In first minute of fire eve

$$q_{eq}\left[\frac{Kg}{m^2}\right] \in [10,50]$$

- Temperature has a line grow of 7.8 °C after 10

$$O = 0.329\, m^{1/2}$$

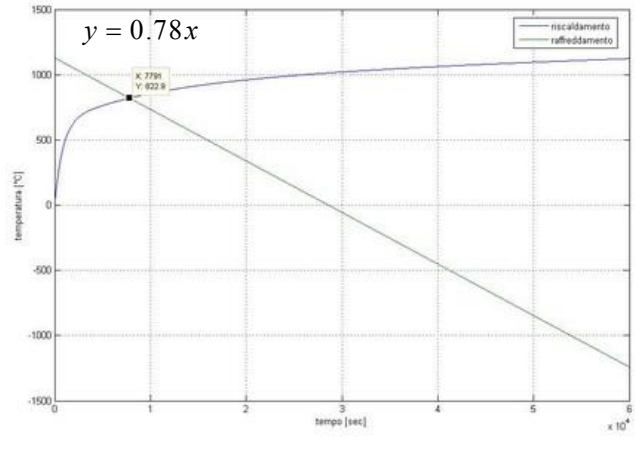
- We set a upper bound 6°C in 10 sec;

$$A_v = 2.1\, m^2$$

$$A_t = 92.5\, m^2$$

$$h = 2.1\, m$$

- 820 °C after flash over at 7800 sec;
- 35 °C after 45 sec from start of fire;



- **Law n. 46 of 5/03/1990 *"Norme per la sicurezza degli impianti"*; D.M. 10/03/1998 *"Criteri generali di prevenzione incendi"*; D.M. n. 569 of 20/05/1992; D.P.R. n. 418 of 30/06/1995**
- **ISO Standard 834 (International Fire Fighter Standard)**

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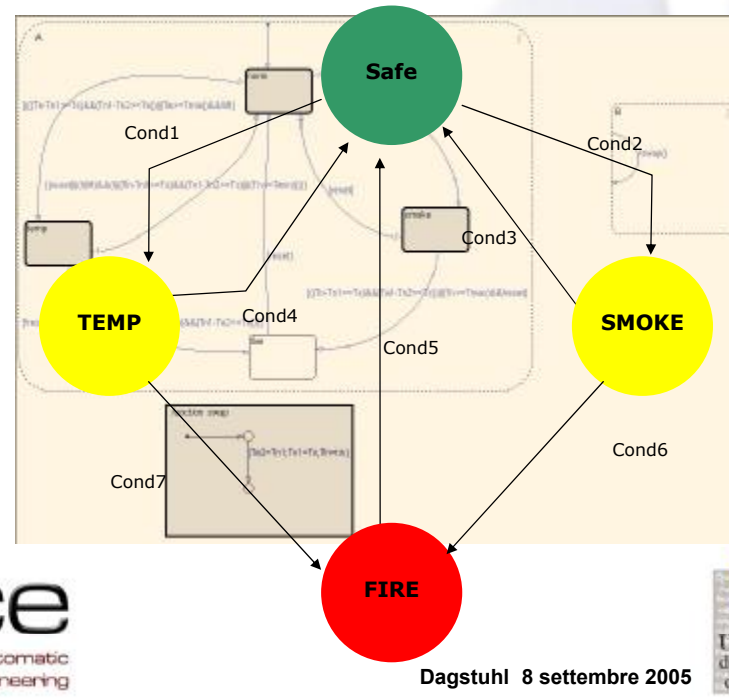
Fire detection finite state machine

- **Condition processed on last 3 temperature samples;**
- **Pre Allarm Temp:**
  - **No smoke Event;**
  - **Temp grows up more than 6 °C in 10 sec;**
- **Pre allarm Smoke:**
  - **Smoke Event;**
- **Fire Allarm:**
  - **Smoke Event and Temp grows up more than 6 °C in next 10 sec;**
  - **Pre allarm Event and smoke Event;**



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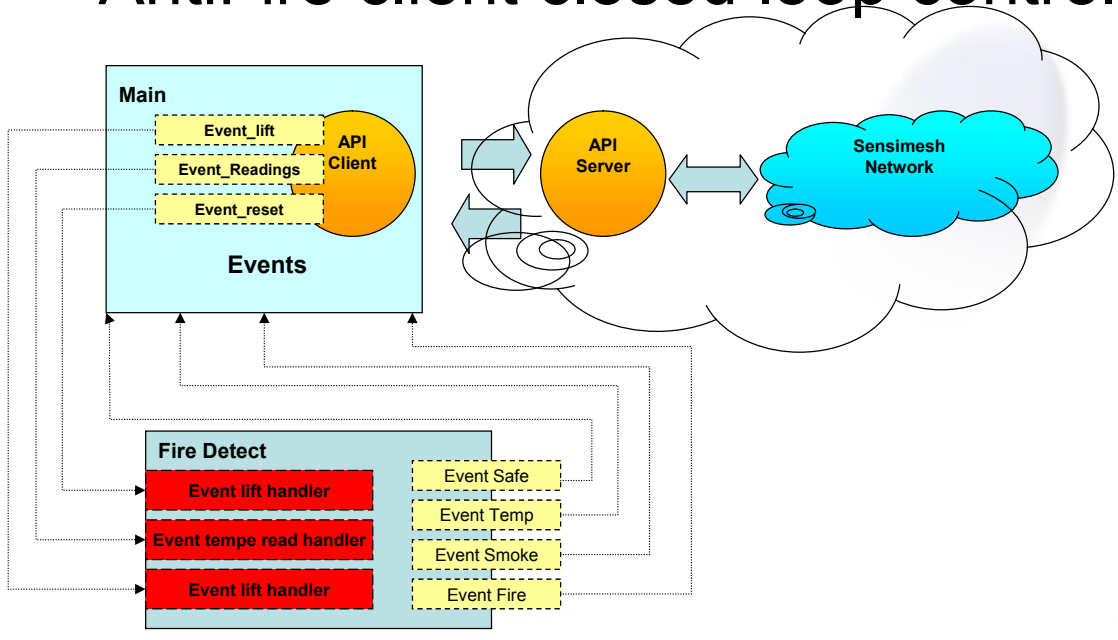
AntiFire client closed loop control



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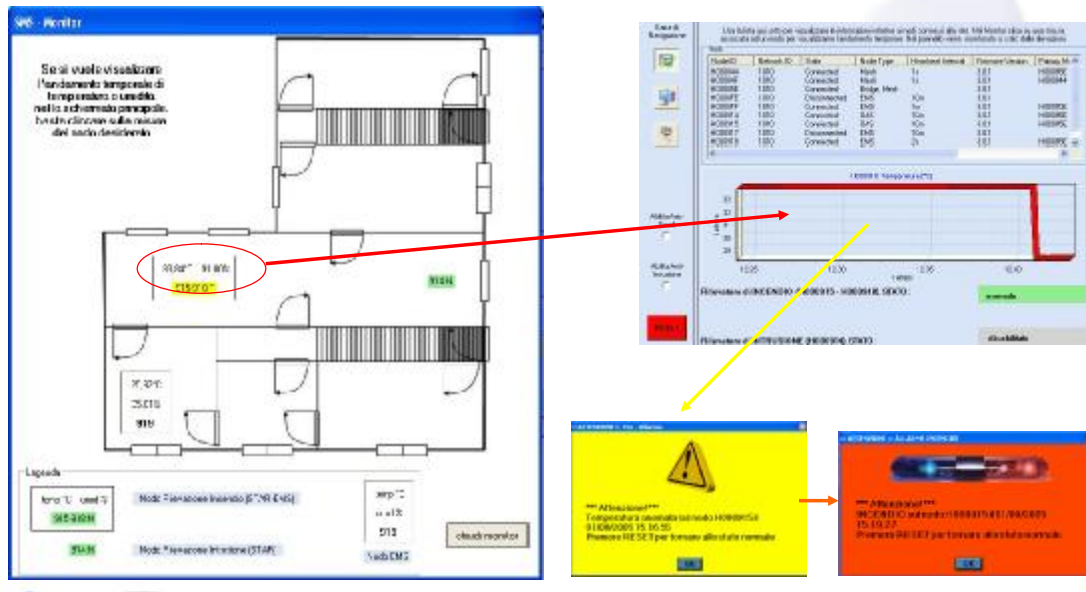
Application user interface



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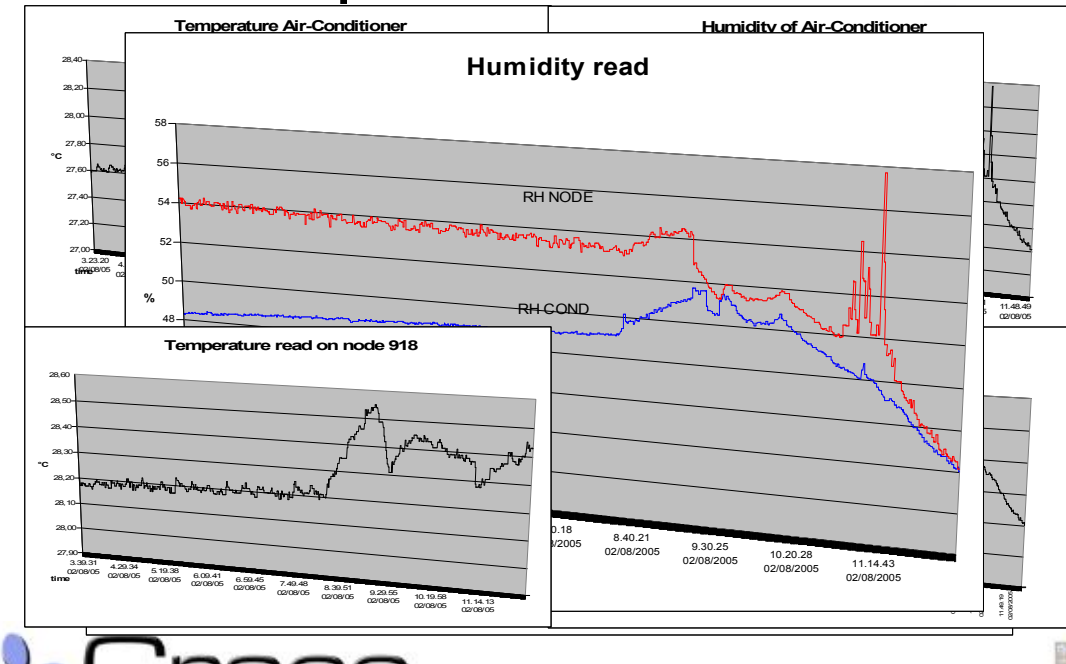
Experimental data



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Thank you so much

- Any questions ?

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