A Fire detection Application on Sensimesh Wireless Sensors Network

Summer school on Wireless Sensor Networks and Smart Objects

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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).
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.

Sensors network

• Sensimesh H900 sensors Network
Network specification

<table>
<thead>
<tr>
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<th>BRIDGE</th>
<th>MESH</th>
<th>STAR</th>
<th>EMS</th>
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<td>External Energy</td>
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<tr>
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<tr>
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Environment & design space

- Manual one-time deployment;
- 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;
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;

Anti-Fire Node

• A smoke sensor connected on a star node port;
• A EMS node to read temperature and humidity;
Using a Sensimesh Network

Fire-Temperature graph

\[ \theta_c = 1235(1 - 0.324e^{-0.2t} - 0.204e^{-3.5t} - 0.472e^{-38t}) \]

\[ \theta_c [\text{°C}] \text{ compartment air temperature} \]

\[ t [\text{hour}] \text{ time} \]

\[ t^*[\text{hour}] = \frac{-t}{\Gamma} \]

\[ \Gamma [\text{hour}] = \frac{O}{b} \]

\[ b [\text{J/m}^3\text{s}^2\text{K}] = (\rho c \lambda)^{1/2} \text{ (variable from 1000 to 2000)} \]

\[ \rho [\text{kg/m}^3] \text{ room walls density} \]

\[ c [\text{J/kg K}] \text{ specific heat of room walls} \]

\[ \lambda [\text{W/m K}] \text{ termic conductibility of room walls} \]

\[ t_f^* [\text{hour}] = 0.13 \times 10^3 q_{in} \Gamma \]

\[ \text{flash over} \]

\[ \text{tempo} \]
In first minute of fire event:
- Temperature has a linear growth of 7.8 °C after 10 sec;
- We set a upper bound of 6°C in 10 sec;
- $T = A^2 / h = 92.3^2 / 2.1 = 928.29^2 / 2.1 = 2.1\ m$
- 820 °C after flash over at 7800 sec;
- 35 °C after 45 sec from start of fire;

Fire simulation parameters setup

\[
y = 0.78x
\]

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;

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)
AntiFire client closed loop control

Application user interface
Thank you so much

• Any questions?