ALERT: A Next-generation Emergency Response System for First Responders using Retasking of Wireless Sensor Networks

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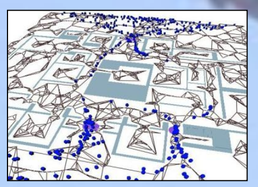
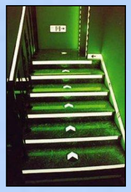
The objective is to design a real-time information system to improve emergency-response functions by bringing together information to respond to a terrorist attack, natural disaster or other small or large-scale emergency

Problems Addressed

Search and Rescue
- ❖ Unique and unknown conditions
- ❖ Lack of real-time information for disaster management


Approach

On the fly retasking approach
- ❖ Targeted towards first responders and evacuations
- ❖ Utilizing independently deployed wireless sensor networks (WSN)
- ❖ Retasking the original sensor networks into short-lived, mission-driven sensor networks


Resulting in
- ❖ Availability of timely and accurate information
- ❖ Better disaster response plans
- ❖ Improved emergency response functions

Objectives

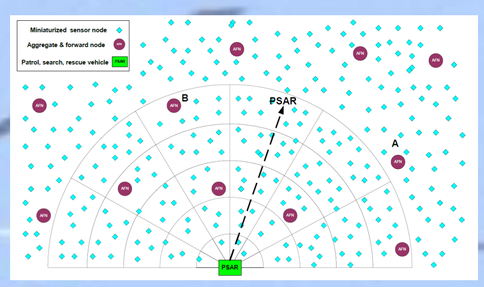
- ❖ Discover and reallocate the available capabilities in individual sensor networks
- ❖ Specify sensor missions and their attributes
- ❖ Retask independently-deployed sensor networks
- ❖ Provide middleware support for retasking independently-deployed sensor networks

Building Blocks

- ❖ **Sensors**: Sends data directly to the assigned AFN
- ❖ **AFN**: Aggregation-and-forwarding node aggregates the data from all sensors in its group
- ❖ **Base station**: Typically a first responder, it receives the aggregated reports from AFNs
- ❖ **Retasking strategies**: Based on emergency type and size
- ❖ **Middleware**: Based on the required Quality of Service

Initiating the Interaction

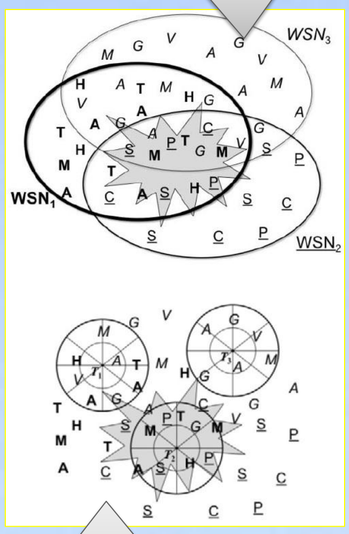
- ❖ ALERT detects the arrival of PSAR (Patrol, search and rescue vehicle/personnel)
- ❖ As PSAR enters area
  - ✓ PSAR authenticated
  - ✓ Trust relationship established
  - ✓ PSAR authorized to retask and utilize services of sensor network
- ❖ PSAR trains sensors in its range
- ❖ PSAR provides middleware and shares short-term mission parameters with neighboring AFNs



Analyzing an Area of Interest

Wireless sensor networks WSN_1, WSN_2 and WSN_3 have been independently deployed over a common area of interest in the vicinity of a chemical plant
- ❖ WSN_1 deployed for environmental monitoring including temperature (T),humidity (H), motion (M), and acoustic (A) sensors
- ❖ WSN_2 deployed for pollution monitoring including air pressure (P), smoke (S), and chemical (C) sensors
- ❖ WSN_3 deployed for traffic monitoring contains video (V), acoustic (A), motion (M), and GPS (G) sensors

Three non-integrated WSNs



The same WSNs, with regions near responders (Ti) integrated by the virtual infrastructure

Let us assume that there was an explosion at the chemical plant. As a result, the factory is on fire, and thick smoke, toxic gases and other hazardous chemicals were released over a large surrounding area. The three networks must be retasked into short-lived mission-driven sensor networks in support of the following high priority missions:

1. Assess the extent and potential effect of hazardous materials
2. Identify and locate survivors
3. Detect the wounded and assess their condition
4. Guide rescue teams to the trapped and the wounded
5. Detect fires, and identify directions of their spreading
6. Detect damaged power lines, leaks from gas lines and hazmat spills

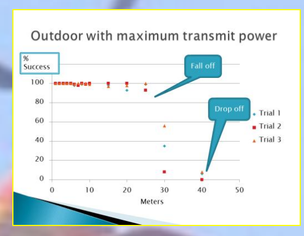
	Types of sensors								
Mission	**T**	**H**	**V**	**A**	**G**	**M**	**C**	**P**	**S**
1	X	X					X	X	X
2				X	X	X			
3			X	X					
4			X		X	X	X		
5	X	X						X	X
6			X				X		X

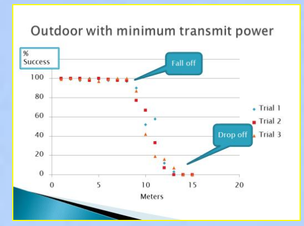
Implementation

Hardware specification
- ❖ IRIS motes
- ❖ WLAN capable Notebook

Software specification
- ❖ TinyOS 2.1.1
- ❖ nesC programming language

Results





Many ZigBee / IEEE 802.15.4-based wireless data networks operate in the 2.45–2.4835 GHz band, and so are subject to interference from other devices operating in that same band

Conclusions

- ❖ The effectiveness of the ALERT system is dependent on the basic transmission capabilities and orientation of motes
- ❖ At shorter ranges (<10m) transmission looks promising with reliability (>95%) at all times
- ❖ At larger ranges (>25m), quality of communications may be acceptable, but repeated tests have show that reliability is very low
- ❖ At medium ranges (10m < X < 25m) communication usually has consistent reliability
- ❖ Orientation of the mote has an effect on its transmission range

Future Work

Further enhancement towards improving disaster management
- ❖ Early warning systems
- ❖ Detecting trends and unanticipated events