VigilNet: An Integrated Sensor Network System for Energy-Efficient Surveillance[1]

A presentation by Bas Schaafsma on the deployment of wireless sensor networks

1) published in ACM Transactions on Sensor Networks (TOSN) 2006

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Introduction to VigilNet and its Application requirements

- Goal: using a wireless sensor network to create a ground surveillance application, measuring both movement and speed of passing vehicles , not just in simulations!
- Requirements:
  - Longevity
  - Adjustable Sensitivity
  - Stealthiness -not just sensor size !-
  - Effectiveness

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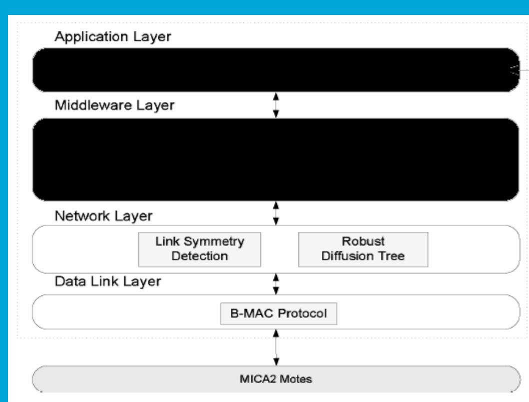
Presentation overview

- Introduction to VigilNet and it's Application requirements
- Deployment setup overview
- Partial System overview
- Time-Driven System Design
- Performance Evaluation
- Lessons learnt
- Conclusion
- Questions?

Partial System overview



Deployment setup overview

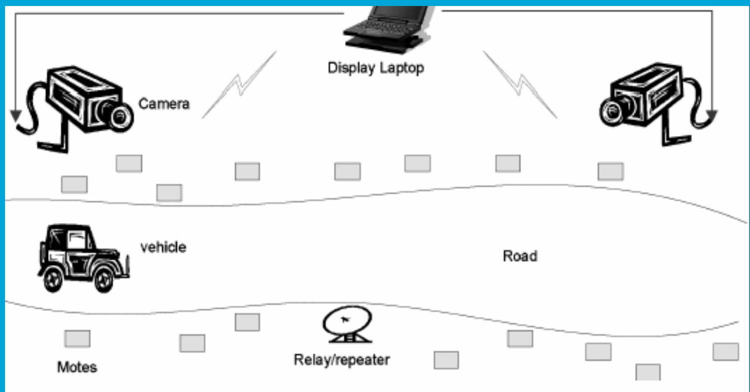


Fig. 1. Sensor network deployment.

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Deployment setup overview

- 70 MICA nodes equipped with a 433 MHz Radio, deployed along a 280 ft long perimeter
- Radio has 255 selectable transmission power
- Nodes have a power supply of 2000mAh at 3V (5 days of power)
- Nodes use magnetic sensors to detect vehicles
- Relay that sends information back to base
- Laptop used for visualization
- Cameras for next level of surveillance

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Time-Driven System Design

overview

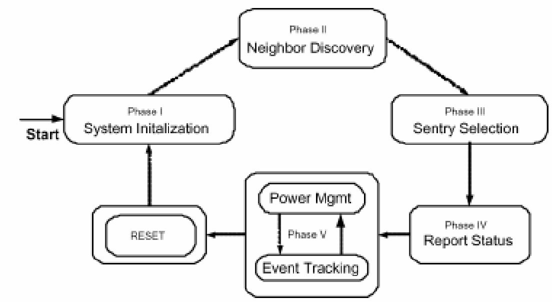


Fig. 3. Time driven system transition.

Time-Driven System Design

System Initialization + Neighbor Discovery

Basic Initialization:

- Time Synchronization
- Diffusion Tree Creation
    - Mote Failures ☹
    - Asymmetric Links ☹
- Dynamic Reconfiguration
- Localization ☹

Neighbor Discovery:

- Find neighbors by broadcasting hello messages

Time-Driven System Design

Sentry Selection + Status Report

Sentry selection conditions:

- internal node of diffusion tree
- None of its neighbors is covered by another sentry

Issues during Sentry Selection

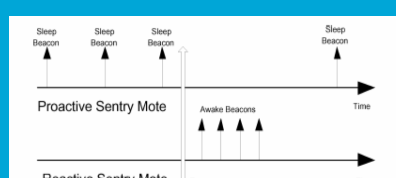
- Race Conditions ☹
- Energy Balancing and Efficiency ☹
- Sensing Coverage ☹

- (optional) Status Report

Time-Driven System Design

Power Management / Event Tracking

- During Power Management we need to:
  - Let non-sentry nodes sleep so that they conserve energy
- Are we Proactive or Reactive?



- During Event Tracking we need to:
  - Report measured movement
  - Apply data aggregation in groups

Performance Evaluation

Evaluation of MICA2 Radio

Table I. Impact of Antenna Lengths on RF Range (Elevation 0 ft)

Antenna	Power level = 50	Power level = 255
17.3 cm	37 ft	43 ft
34.6 cm	59 ft	> 84 ft

Table II. Impact of Elevations on RF Range

Elevation	0 ft	0.5 ft	1 ft
Mote A	27 ft	30 ft	> 84 ft
Mote B	43 ft	> 84 ft	> 84 ft

- Antenna size matters
- Height maters

Performance Evaluation

Evaluation of Symmetry Detection

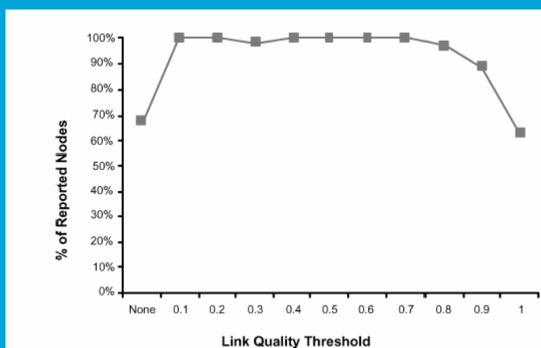


Fig. 10. Performance evaluation of asymmetry detection service.

Link Quality Threshold = The percentage of times your own id appears in a beacon message sequence

Link Quality threshold does not have to be high, but to too high is unrealistic

Performance Evaluation

Evaluation of in Network Aggregation

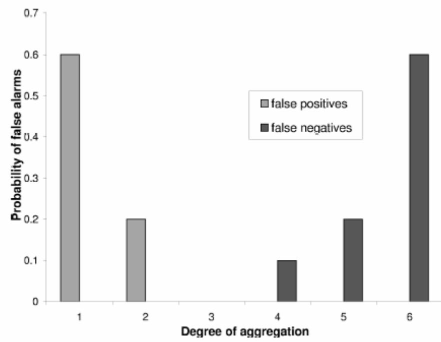


Fig. 12. Impact of DOA on false alarms.

Network Aggregation can be used to greatly reduce false alarms, but a high level might result in lost data

Performance Evaluation

Evaluation of Sentry Service

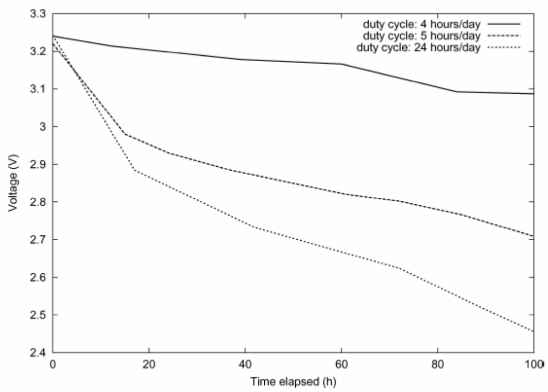


Fig. 17. Impact of sleep duration on power consumption.

Even a small increase in duty cycle can lead to a dramatic decrease in lifetime

Performance Evaluation

Evaluation of Sentry Service

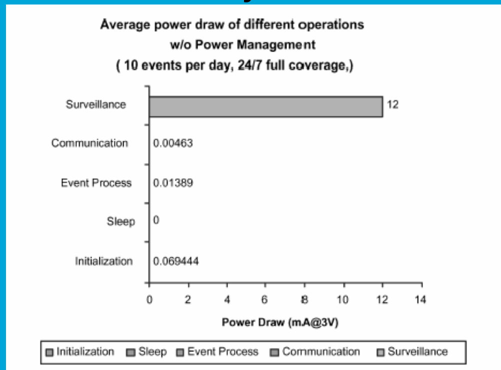


Fig. 14. Power draw of different operations.

Most power is not expended during communication but during surveillance!

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Lessons learnt

- After completion of the deployment the following lessons were learnt:
    - Asymmetry Reduction
    - False Alarm Reduction
    - Application-Specific Reliability
    - Race Condition Reduction
    - Software Calibration

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Conclusion

Goal: using a wireless sensor network to create a ground surveillance application, measuring both movement and speed of passing vehicles, not just in simulations!

It is clear that key realistic hardware software and environmental issues must not be ignored in developing solutions. Such issues include sensor performance, asymmetries in communication, false alarms and race conditions

Questions?

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