Power Consumption Attacks in Wireless Sensor Networks

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Outline of today's talk

1. Introduction
   - Topics
   - Motivation
2. Methodology
   - Overview
   - Battery Behavior
   - Attack Simulations
3. Results and Analysis
   - Simulation Results
   - Mitigation Strategies
4. Conclusion
   - Future Work

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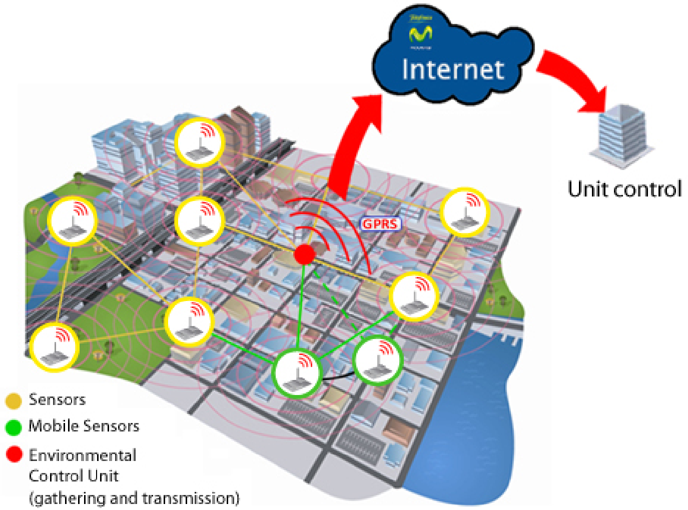
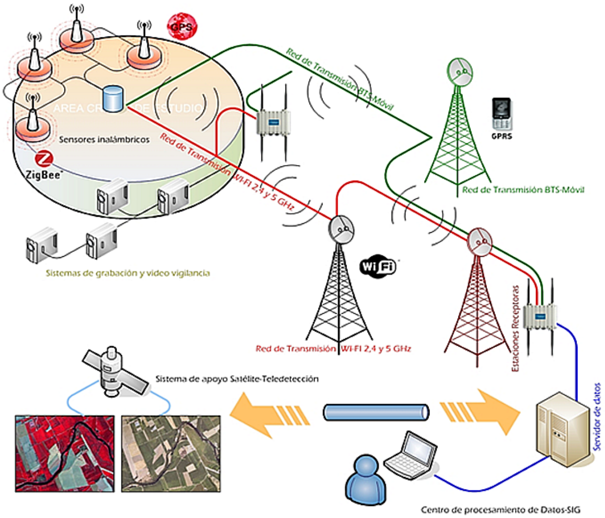
Wireless Sensor Networks(WSNs)

- A **wireless sensor network(WSN)** is a network of **Sensor Nodes**
- **Sensor Nodes** send and receive wide varieties of data.
- **Sensor Nodes** generally operate in one of two states:
    - **Sleep Mode** - less power draw, but can't receive and transmit
    - **Active Mode** - more power draw, and can receive and transmit

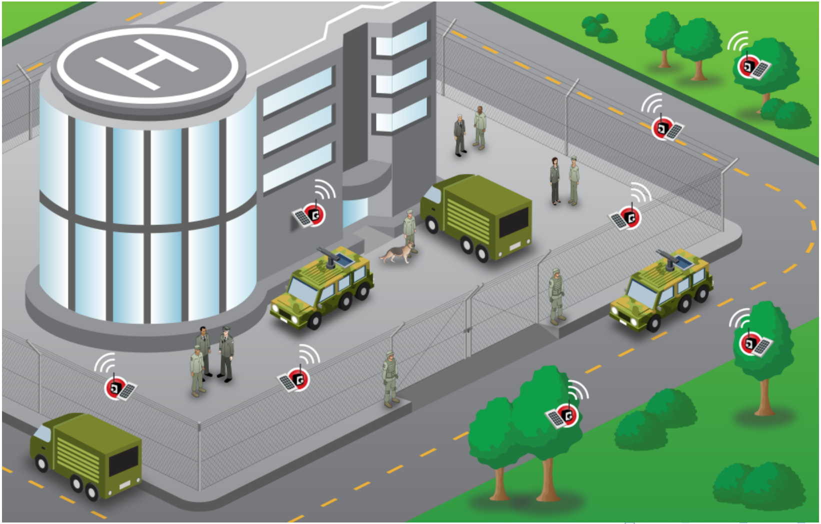
WSN examples (1) - p.H. and flow



WSN examples (2) - fire detection and prevention



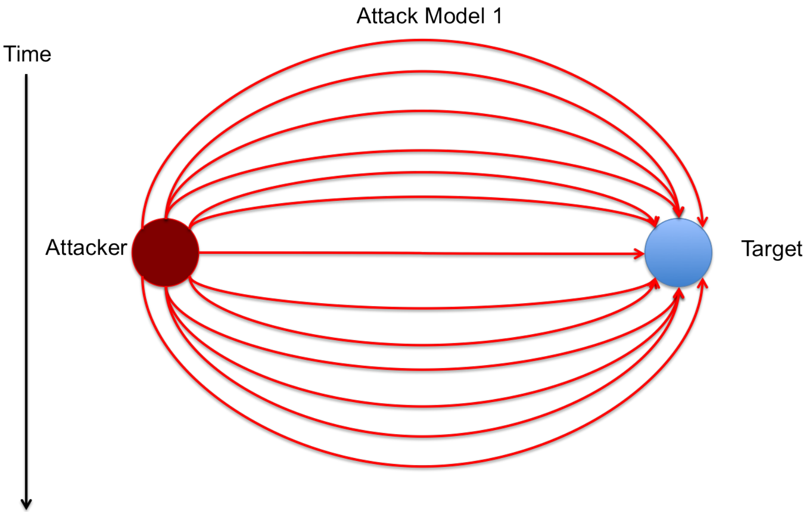
WSN examples (3) - security systems



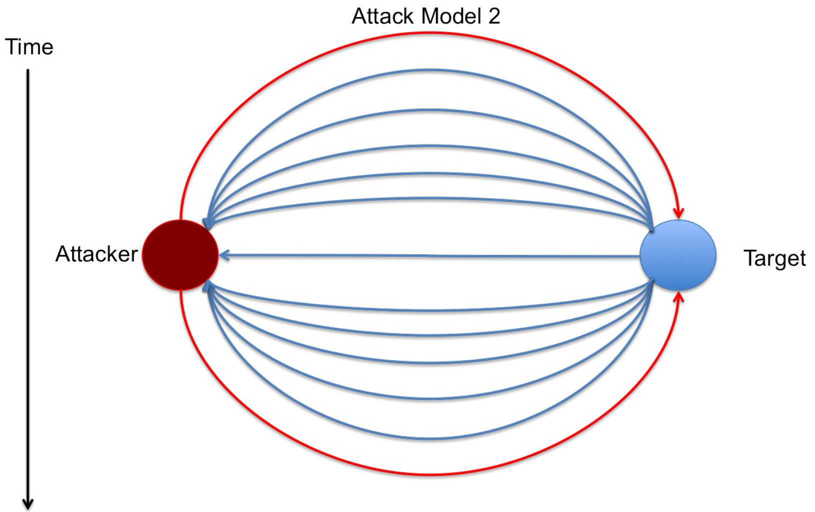
Attacks on WSN power supplies

- **Sensor Nodes** are developed in bulk for mass deployment
- Bulk production has robbed WSNs of more robust **battery lives**
- limited battery lives make sensor nodes easy targets for **Power Consumption Attacks**
- A **Power Consumption Attack** drains the battery power of sensor nodes by forcing **meaningless active mode time**.
- Attackers hope to gain something by compromising nodes:
  - Protocol information for other attacks
  - temporary system downing
  - permanent system downing
  - competitive advantage
- Here we show some of our attack models

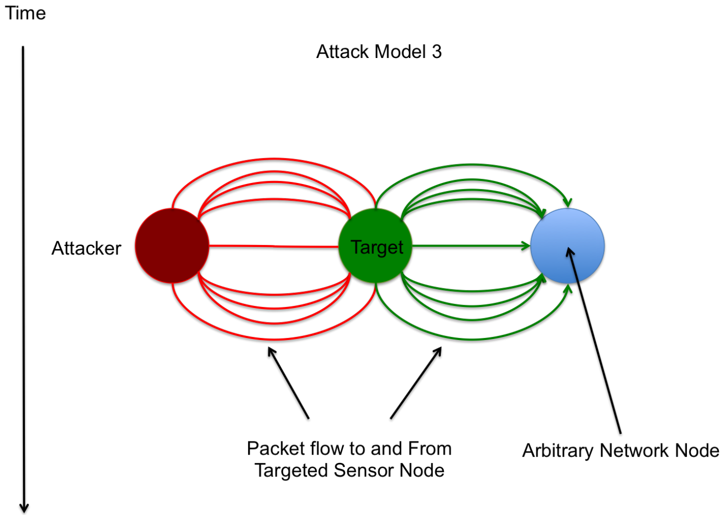
Attack Models (1) - standard denial of sleep



Attack Models (2) - inverse denial of sleep



Attack Models (3) - routing power draw



Problem

How do we defend against a wide range of Power Consumption Attacks?

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Overview

- we simulated **standard denial of sleep attacks** and **routing power draw attacks** on WSNs
- we first examined different **batteries**
- we then simply examined the **time to compromise** a node under various different assumptions

Battery Tests

- The logical conclusion to mitigate the risks of **Power Consumption Attacks** is to use more powerful **batteries**
- The batteries tested were:
  - Lead-Acid Batteries
  - Alkaline Long-Life Batteries
  - Carbon-Zinc Batteries
  - NiMH Batteries
  - NiCad Batteries
  - Lithium Ion Batteries
- With weights varying from **0.1 mg** to **1 mg**
- And Packet sizes varying from **2 bits** to **1 kb**
- We got approximately **700** simulation results from NS3
- packets were sent every **10 ms** in this simulation

Attack Simulation

- The attacks were simulated in an environment that allowed user defined:
    - Packet Size (bits)
    - Initial Node Energy (joules)
    - Power To Transmit Messages (Watts)
    - Power To Receive Messages (Watts)
    - speed of Transmission radios (bps)
- Each of these were variate for **55,000** simulations

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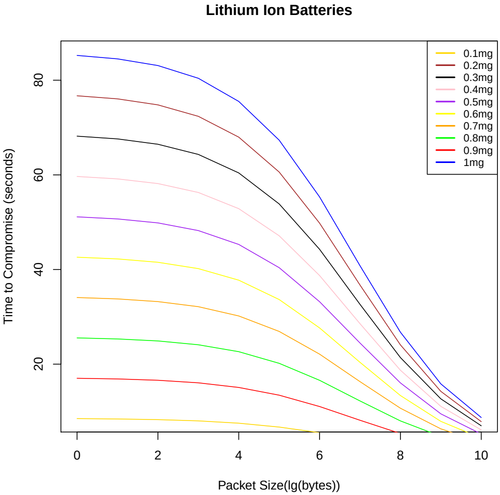
Battery Analysis(1) - Compromise Statistics

B-Type	TTC(Min)	MTTC	TTC(Max)
Lead Acid	0.2789 s	9.8798 s	27.0307 s
Alkaline Long Life	0.7589 s	27.1017 s	74.1107 s
Carbon-Zinc	0.2489 s	8.7950 s	24.0700 s
NiMH	0.6489 s	23.0336 s	62.9907 s
Nickle-Cadmium	0.2689 s	9.4734 s	25.9207 s
Lithium-Ion	0.8689 s	31.1701 s	85.2400 s

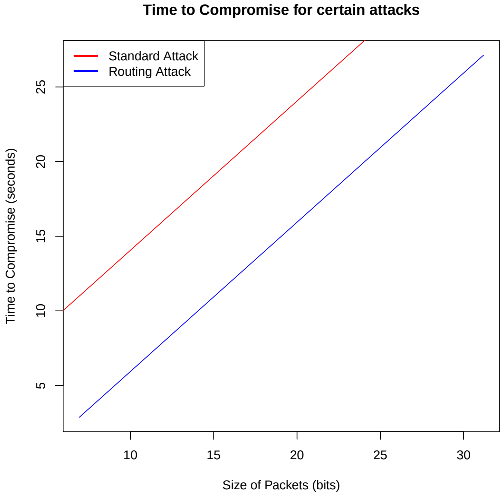
- **B-Type** = Battery Acid Type
- **TTC(Min)** = Minimum Time to Compromise w/ std attack
- **MTTC** = Mean Time to Compromise w/ std attack
- **TTC(Max)** = Maximum Time to Compromise w/ std attack
- as expected Lithium Ion Battery is most effective

Battery Analysis(2) - Varied Weights



Comparing Attacks(1) - Compromise Statistics

Comparing Attacks



Previous Strategies

- Some **risk mitigation strategies** have already been adopted for use in WSNs:
  - **Predefined Transfer Windows**
  - **Node Reception Memory**
  - **Jamming Detection Protocols**
  - **Low Power Wake-up Radio**
  - **Defined Maximum Path Length**
- Many strategies are developed with specific attacks in mind
- Even our proposed strategies have already been deployed

Proposed Strategies

- Because the Routing attack we examined is much more potent examination of routing procedures should be carfully examined
- the possibility of placing nodes so they do not have to route should be considered for small crucial WSNs
- Targeted the root problem of all Power Consumption attacks: **pre-defined battery life**
- Installation of solar panels and other similar power regeneration devices.
- Attacks can still be mounted on the network, but would have to fight a endlessly renewing power source
- This addition could be costly, and distributors would need to shrink the size of their network
- But it is up to the distributor to examine there expected net benefit

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Future Work

- Model and test additional attack types
- Do a cost benefit analysis of different types of **batteries** and **alternative power sources**
- compare cost benefits of other mitigation strategies

Thanks

Thanks for Listening! Questions?