Semantic Networking of Sensor Systems for In-Network Processing

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Motivation

- Environmental applications are fundamentally limited by energy
- Require long-term deployment
- Characterized by stasis, punctuated by extreme events on short time scales
- Broad frontier of scientific inquiry devoid of viable instrumentation

How Study Ecosystem of Brazilian Free-tailed Bats?

- Kunz et al.

- How impact ecosystem?
- Millions of bats
- Foraging area in 1000's of sq Km

- How instrument with sensors?
- Correlate enviromental parameters with occurrence of bats
- Measure what we can…in a SNET

High-Level Approach

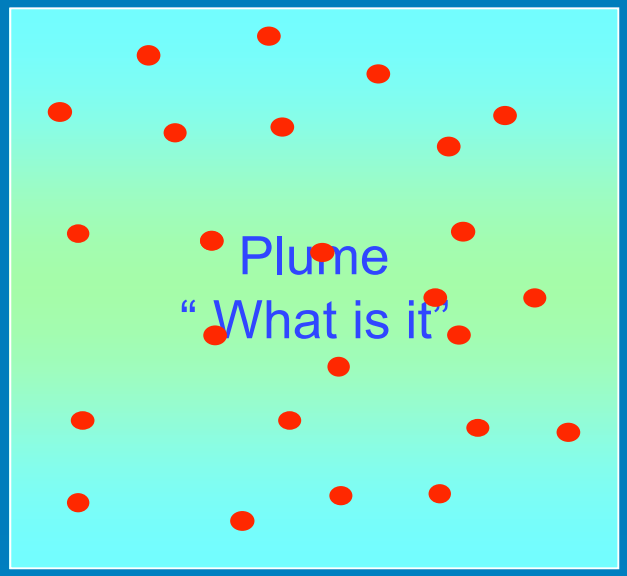
- Semantic, attribute-based routing
- In-network, distributed information processing
- Application guided by discipline experts -- biology, geography (bats, soil moisture dynamics)

Attribute-Based Routing - Synopsis

- Sensors assigned attribute values (e.g., location, sensed parameters)
- Define relationships within the attribute scheme (e.g., containment, neighbors, etc.)
- Use attributes to define clustering and overlay
- Addressing achieved with attributes
- Explicit use of attribute hierarchy in routing/addressing -- not fixed -- permits intersection of different addressing schemes, flexibility

S. Venkatesh, M. Alanyali : M-Ary Hypothesis Testing in Sensor Networks: CISS04
S. Venkatesh, Y.Shi, W. Karl: Performance Guarantees in Sensor Networks: ICASSP04

Inferencing as In-Network Processing

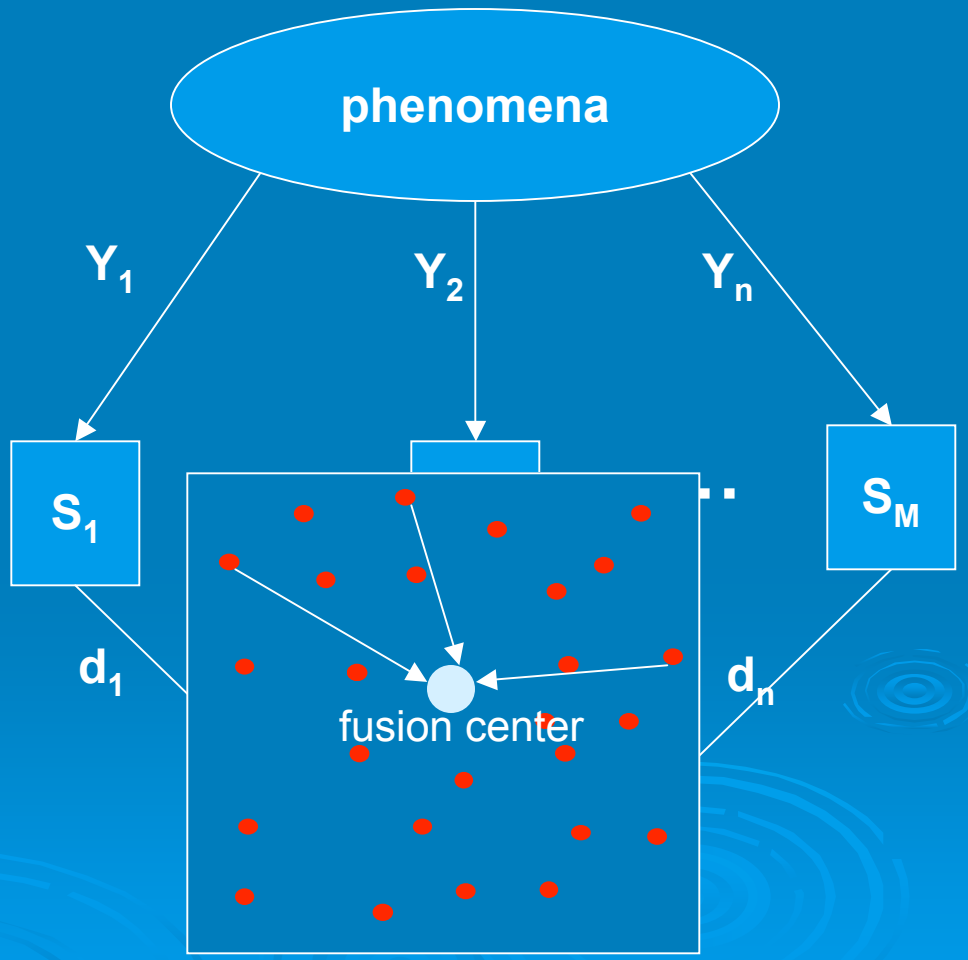


Is it a plume of toxin? What kind of a plume?

Are conditions right for insect emergence?

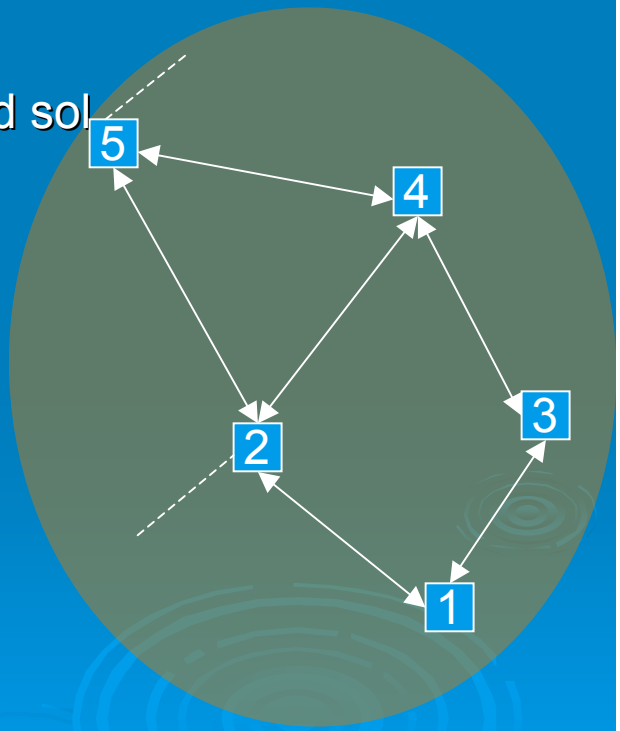
Fusion Center Model

- Setup:
  - Y - measurements
  - decisions: {0,1}
  - fixed # bits communicated
- Broadcast/multihop transmission to fusion center
  - Energy inefficient
- Issues
  - Fusion center evaluates the rules (quality of each sensor)
  - Intractable -- with every sensor's rules
  - Single point of failure



Distributed Classification

- Setup:
  - decisions: $\{p_1, p_2\}$ (30% plume A, 70% plume B)
    - don't make local decisions
    - sensor j to its neighbor k
    - Belief propagation -- converges to centralized sol
    - A collaborative algorithm
- Benefits:
  - Short distance comm.
  - Lower delays in comm.
  - Lower energy in comm.
  - Arbitrary network
  - Works with severe quantization of values
  - Does not require fusion center



Summary

- Energy conservation via in-network processing and attribute-based routing
- Environmental event detection leading to more detailed data collection and SNET actuation
- Targeting application for understanding bat ecosystem