Title
The Impact of Spatial Correlation on Routing with Compression in Wireless Sensor Networks

Authors
Sundeep Pattem
Bhaskar Krishnamachari
Ramesh G

Publication Date
2003

The Impact of Spatial Correlation on Routing with Compression in Sensor Networks

Sundeep Pattem[1], Bhaskar Krishnamachari[1], Ramesh Govindan[2]
1. ANRG, EE-Systems, USC: http://ceng.usc.edu/~bkrishna/anr, 2. ENL, CS, USC: http://enl.usc.edu

Data Gathering and Aggregation: Schemes for Routing with Compression

Data-Centric Routing

- **Data Aggregation**

This is widely accepted as ***an essential paradigm for energy-efficient operation*** of sensor networks. For data-gathering applications in which data originates at ***multiple correlated sources*** and is routed to a single sink, aggregation would primarily involve in-network compression of the data.

Designing routing schemes

- **What is lacking in earlier work?**

-- Several data aggregation schemes have been proposed

-- we seek to understand the ***performance of various data aggregation schemes across the range of spatial correlations***

-- Intuitively, ***optimal routing*** would depend on the ***level of correlation*** in the data originated by sources, requiring an ***adaptive element*** in the routing scheme.

Optimal Routing with Compression:

Are there efficient schemes that are independent of the level of correlation?

• Our result shows that while the nature of optimal routing with compression does depend on the correlation level, surprisingly, there exists a practical static clustering scheme which can provide near-optimal performance for a wide range of spatial correlations.

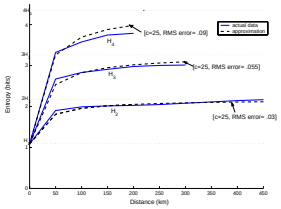
• This result has important consequences—it obviates the need for sophisticated routing and compression schemes, or adaptive schemes that require the underlying correlations in the data to be "learned".

Methodology: Study generic routing+compression schemes to obtain deeper insights for design

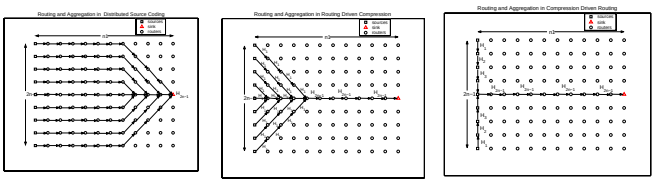
Model and Metrics

- **Metrics**
  - Energy expenditure : bits x hops metric
  - Uncorrelated data gathered : joint entropy of sources
    - Empirically obtained approximation
    - For n sources in a line, separated by d, having correlation level c,

$$H_n(d) = H_1 + (n-1)\left[1 - \frac{1}{\left(\frac{d}{c}\right)+1}\right]H_1$$



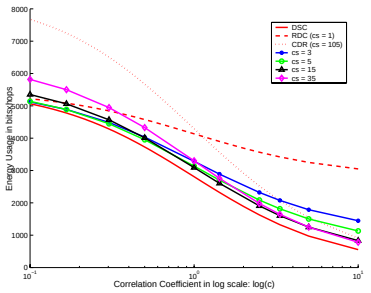
- **Generic Routing Schemes**
  - Distributed Source Coding (DSC) - Idealized, Optimal
  - Routing Driven Compression (RDC) - Shortest paths, compress en-route
  - Compression Driven Routing (CDR) - Compress close to sources



  - RDC and CDR are extremes of a clustering scheme
    - In RDC, each source is a cluster in itself, optimal for c=0
    - In CDR, all sources are part of a single cluster, optimal for c= ∞

Results

- **Hybrid Scheme: Intermediate Cluster size**
  - Optimal cluster size depends on correlation level c
  - ***A particular cluster size is close to optimal over the range of c***



• We prove the existence of such a cluster size analytically using an appropriate definition for the near-optimal cluster size

- **Extension to a 2-D deployment of sources**
  - A simple scheme based on static, localized clustering
  - Similar results as in 1-D case