Synopsis Diffusion for Robust Aggregation in Sensor Networks

Introduction

- Wireless Sensor Networks
    - Air pollution monitoring
    - Landslide detection
    - Data logging (i.e. Smart Grid)

Sensor Networks

- Conserve energy
  - Different algorithms -> Different consumption
  - Different topologies -> Different consumption
- Tree topology
  - Conserves energy and ensures no duplicate messages
  - What happens if a branch is lost?

Sensor Networks

- In a typical sensor deployment, 20-30% of messages are lost
- Solve with multi-path topologies?
- Solve with resending?

Synopsis Diffusion

- Decouples the aggregation and routing
- Achieved through order- and duplicate-insensitive (ODI) synopses

Synopses

- Synopsis generation (SG)
- Synopsis fusion (SF)
- Synopsis evaluation (SE)

Synopsis Diffusion

Two phases:

- Distribution phase: Aggregation query flooded through network
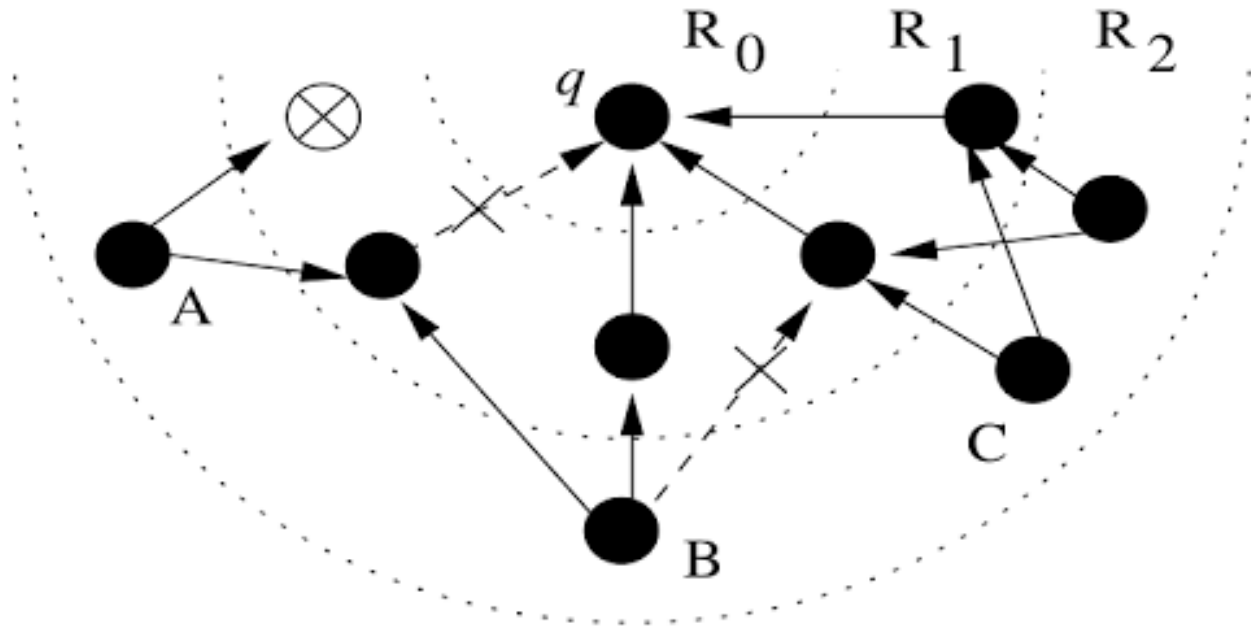- Aggregation phase: Aggregate values continually routed towards querying node

Rings Topology

Rings formed under distribution phase

- Querying node in ring R_0
- Node is in ring R_i if *i* hops from querying node

Rings Topology

Issues

- Topology needs to be adapted to unpredictable node failures
- Explicit acknowledgements?

Implicit acknowledgments

Node u transmitting synopsis x to node u'

If node u' transmits synopsis z such that

z = SF(x,z)

u can infer x *effectively* included in z

Better topology

Adaptive Rings

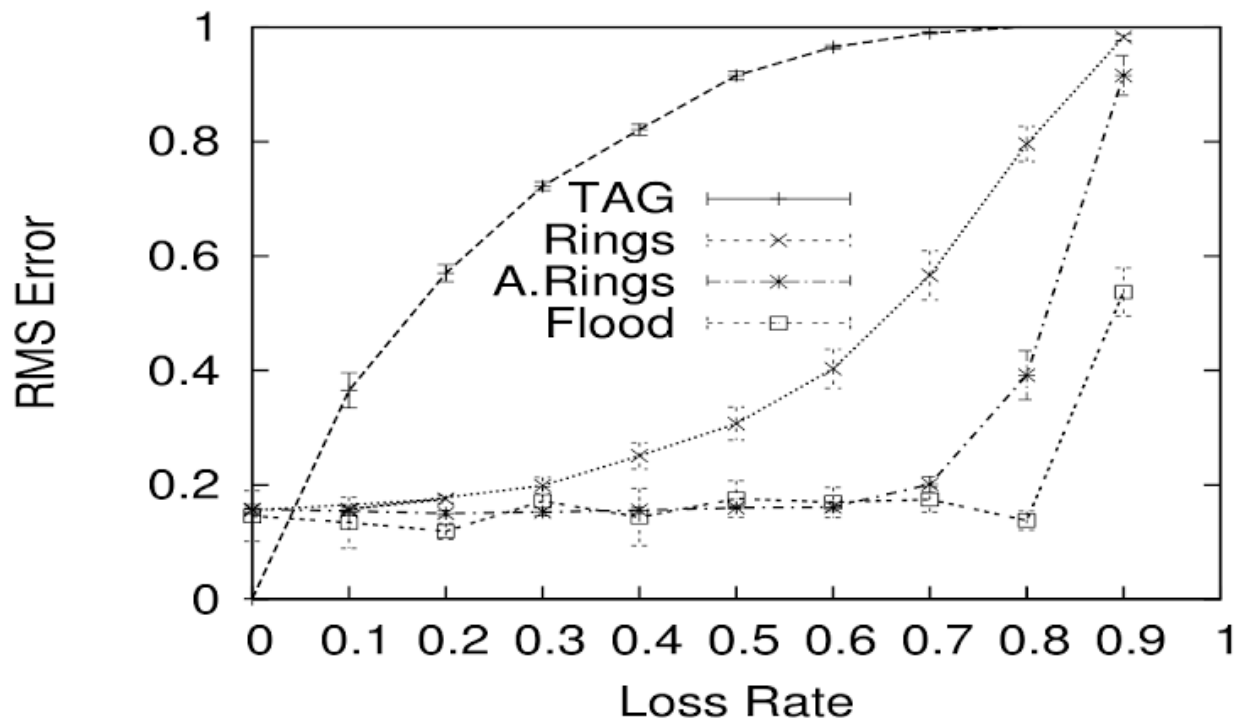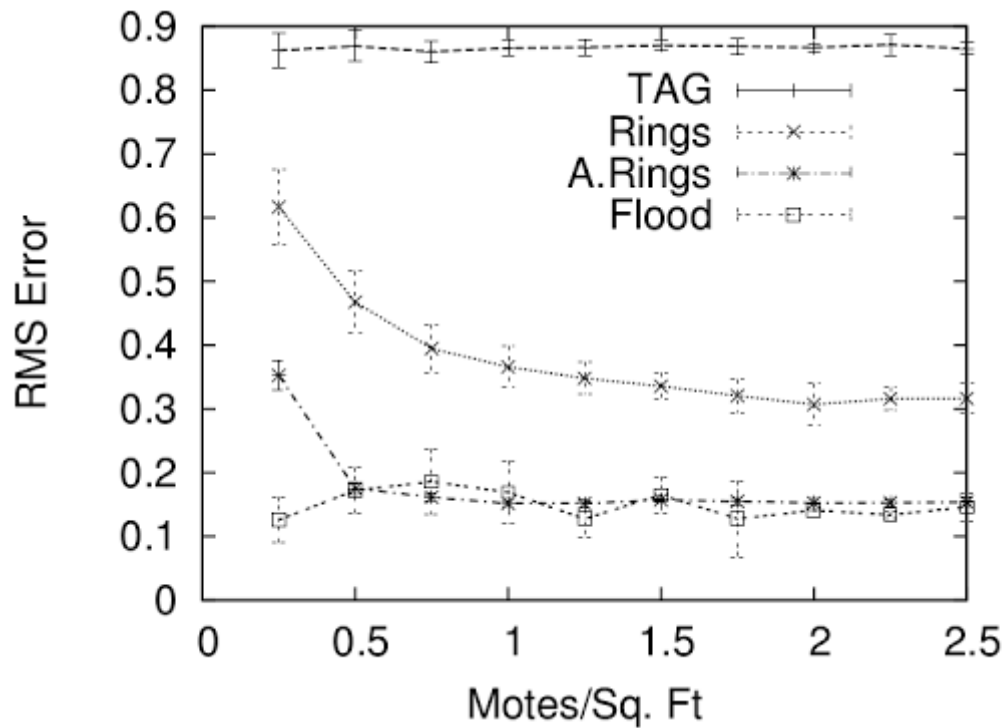● Node u may assign to new ring if too few synopses are *effectively* included

Evaluation

Scheme	% nodes	Error(Uniform)	Error(Skewed)
TAG	$< 15\%$	0.87	0.99
TAG2	N/A	0.85	0.98
RINGS	65%	0.33	0.19
ADAPT. RINGS	95%	0.15	0.16
FLOOD	$\approx 100\%$	0.13	0.13

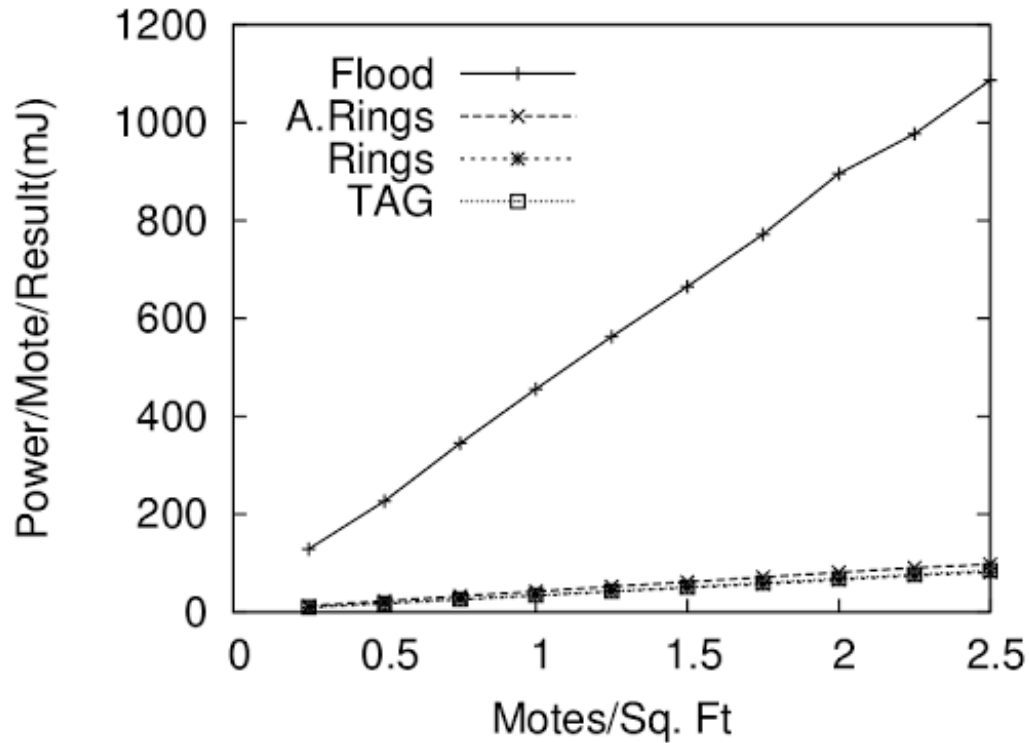Figure 5: Comparison of aggregation schemes
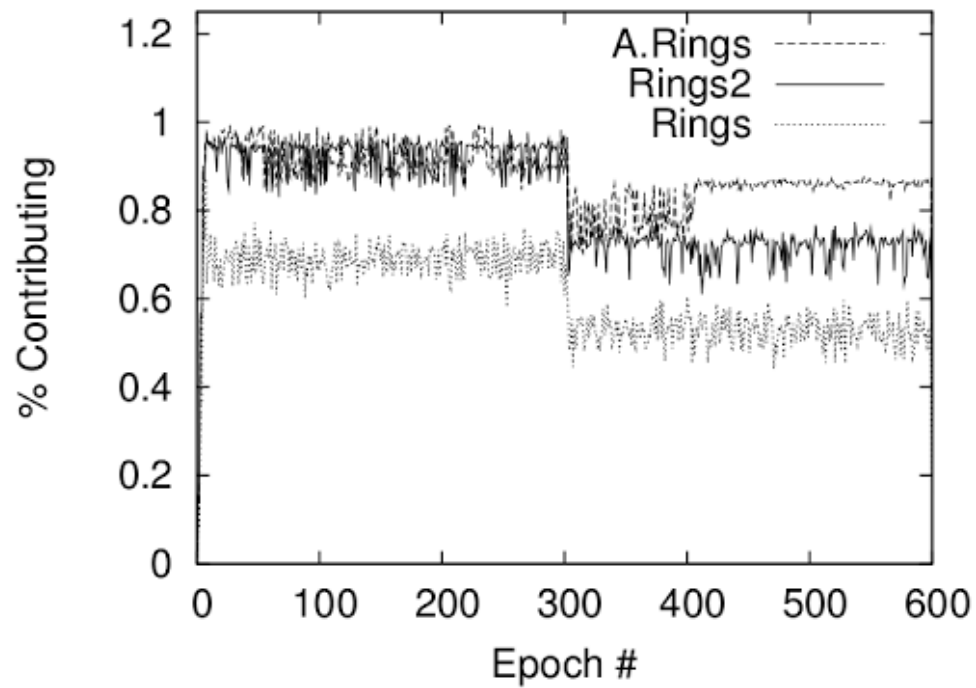
Evaluation

Evaluation

Evaluation

Evaluation

Evaluation

Clearly, Adaptive Rings is superior to both Rings and the ordinary Tree topology w.r.t. handling node failures.

Lower power consumption -> lower node replacement frequency

Questions?