

Structure-free Data Aggregation in Sensor Networks

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Outline

- ❖ Introduction
- ❖ Structure-free Data Aggregation
- ❖ Simulation Results
- ❖ Conclusion



Energy consumption for executing 3000 instructions is equivalent to sending a bit 100 meters by radio.

— G.J. Pottie and W.J. Kaiser
Wireless Integrated Network Sensors

Data Aggregation

- ❏ In-network processing
- ❏ Reduces communication cost
- ❏ Increases trust in measured values

Approaches

Cluster-Based

 LEACH

 PEGASIS

Tree-based

 Directed Diffusion

 TAG



Structure-free Data Aggregation

❏ Packets need to be in the right place...

❏ Spatial Convergence

❏ ... at the right time

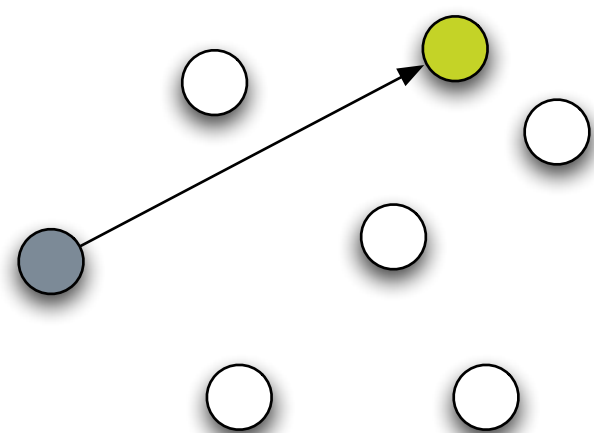
❏ Temporal Convergence



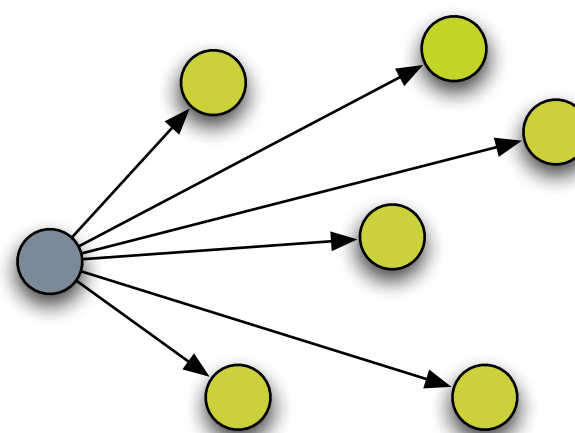
Design Goals

- ❖ **Early aggregation**
- ❖ **Tolerance to event dynamics**
- ❖ **Robust to interference**
- ❖ **Fault tolerance**

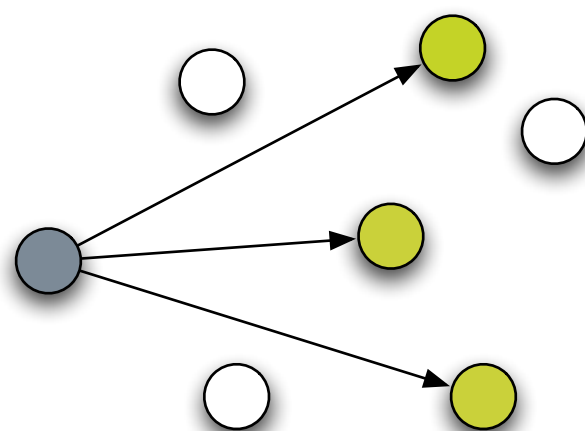
Anycast



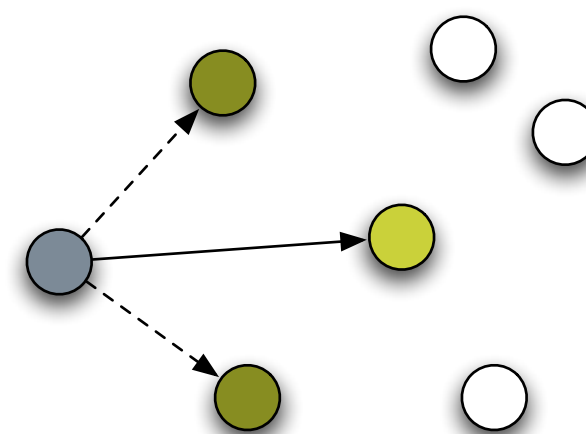
Unicast



Broadcast



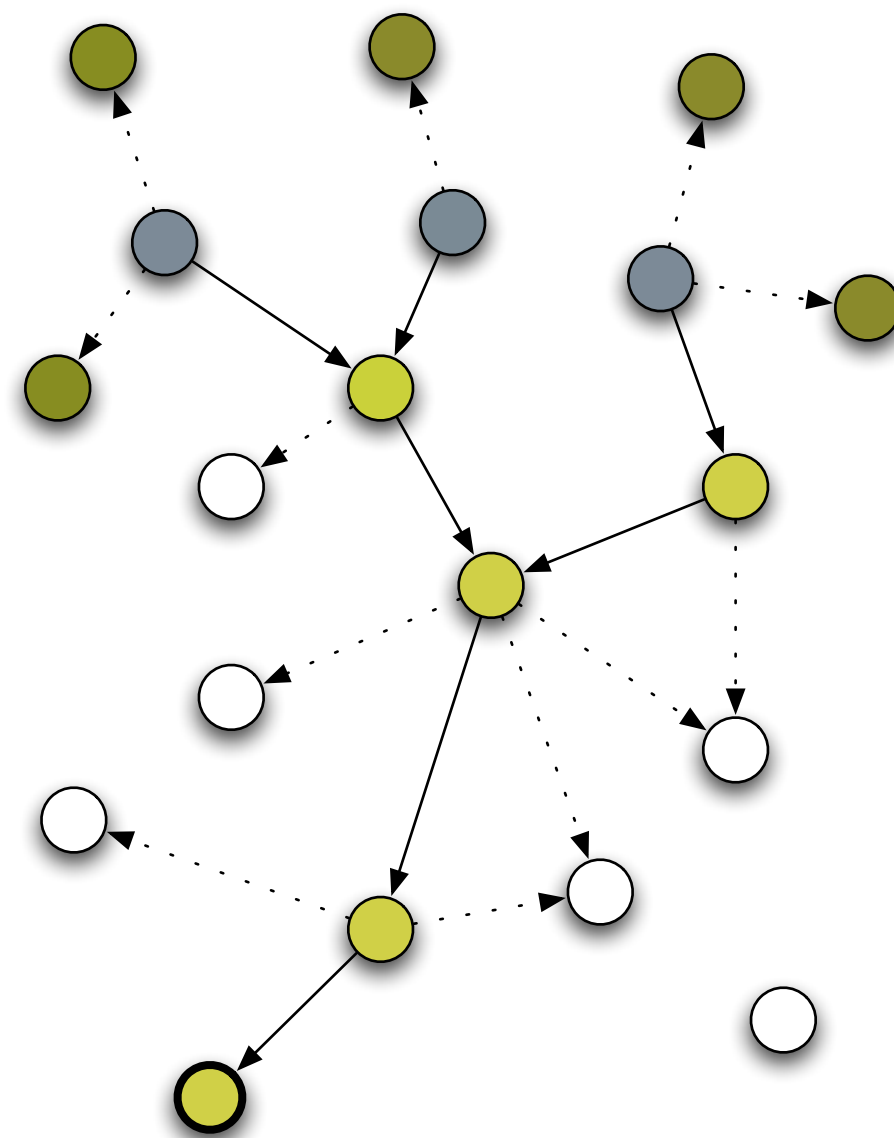
Multicast



Anycast

Data-Aware Anycast

- ❖ Improve Spatial Convergence
- ❖ MAC layer protocol
- ❖ Anycast to neighbor nodes for immediate aggregation
- ❖ Enhancement: Use anycast for forwarding packets
- ❖ CTS priorities depending on distance to sink and aggregatibility



Randomized Waiting

- ❏ Improve Temporal Convergence

- ❏ Application layer protocol

- ❏ Naive Approach

 - ❏ Delay based on proximity to sink

 - ❏ closer to sink → higher delay

 - ❏ Delay proportional to the size of the network

 - ❏ large network → large delay

- ❏ Solution: Random Delay at the sources

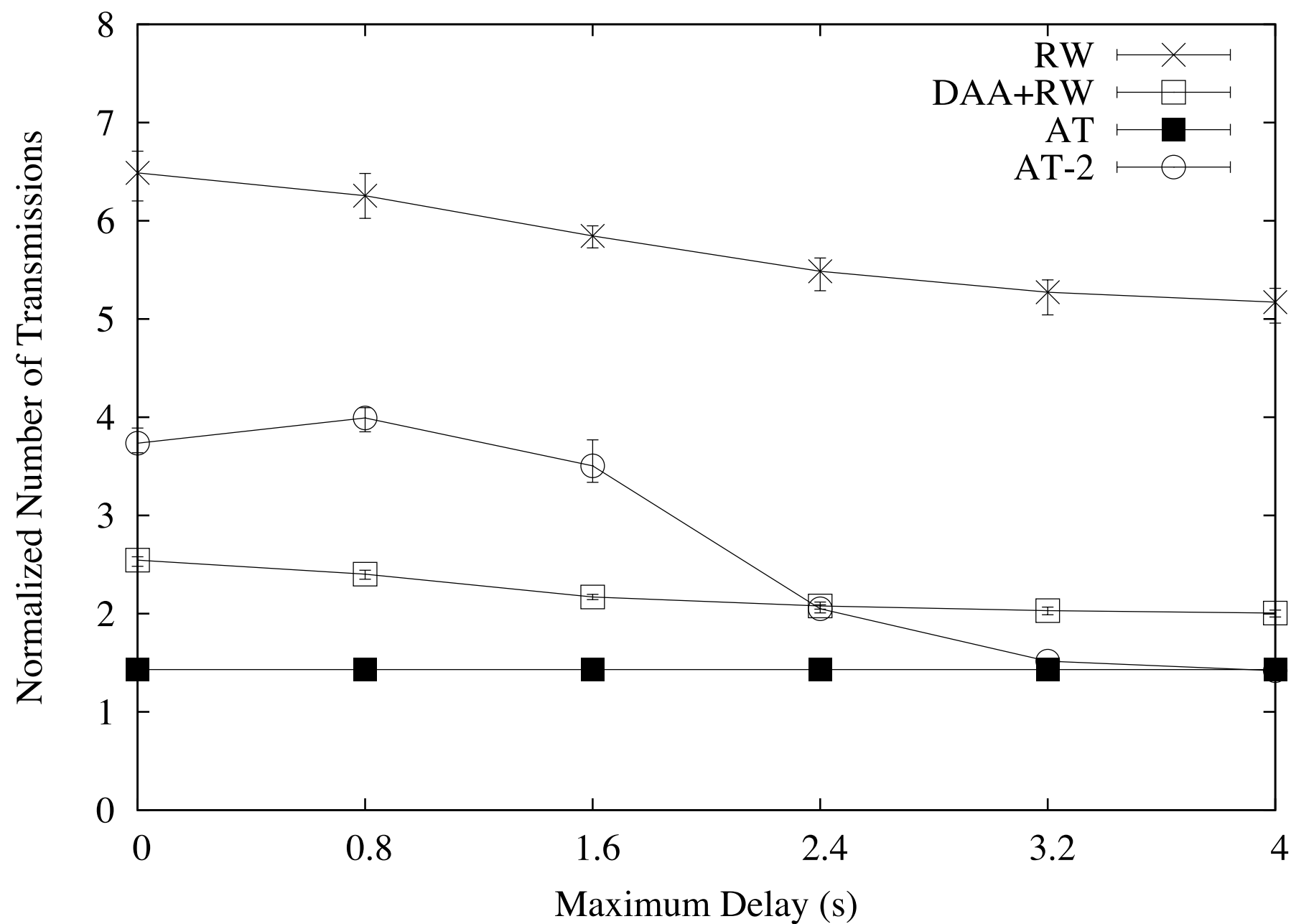
Simulation Setup - Scenario

- ❖ 1000m × 1000m square grid
- ❖ Event size 200m radius at 10 m/s
- ❖ Send packets to the sink every 5 seconds with 50 byte payload
- ❖ Evaluation metric: Normalized Number of Transmissions

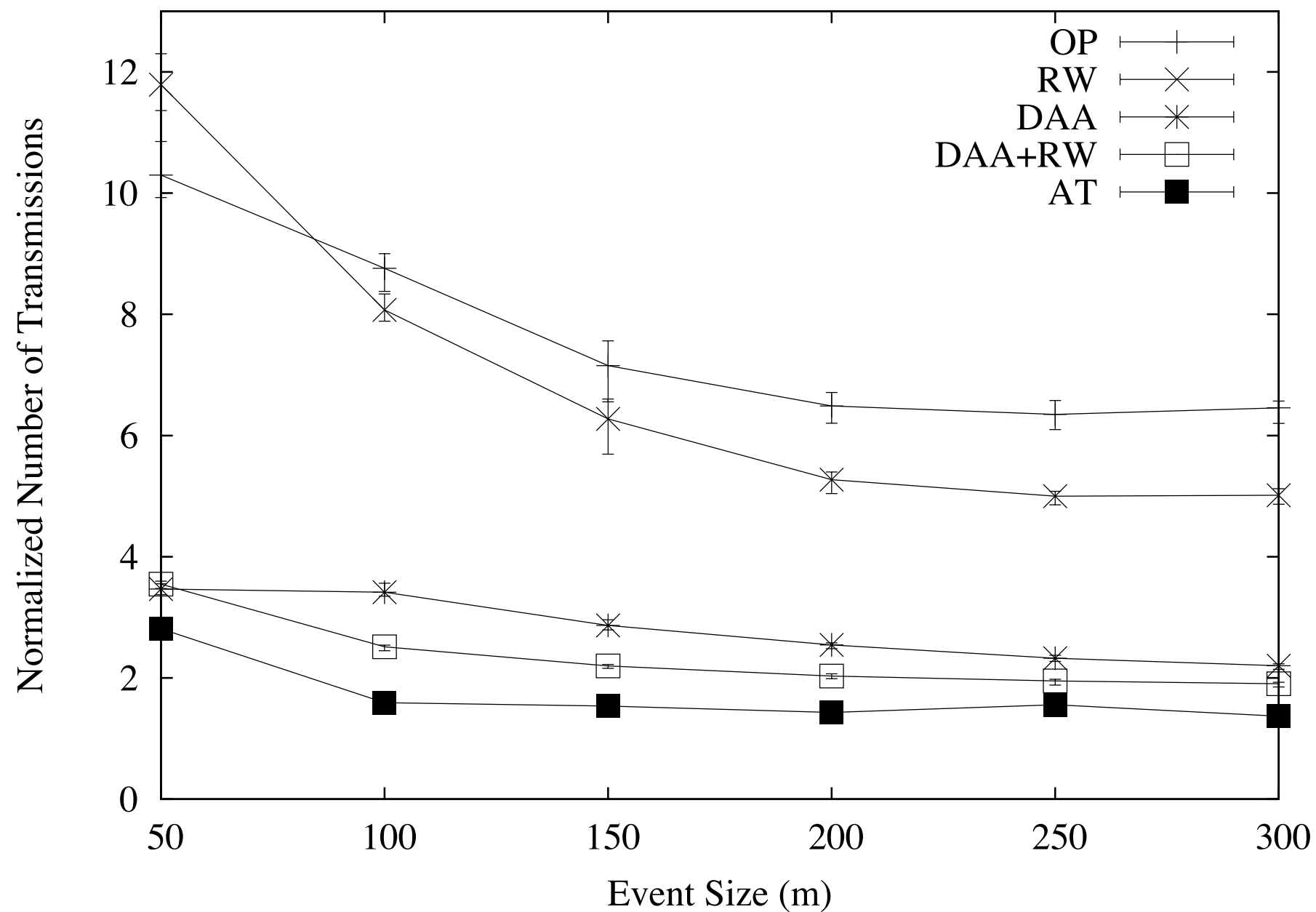
Simulation Setup - Protocols

- ❖ **Opportunistic Aggregation (OP)**
- ❖ **Optimum Aggregation Tree (AT)**
- ❖ **Data-Aware Anycast (DAA)**
- ❖ **Randomized Waiting (RW)**
- ❖ **DAA+RW**

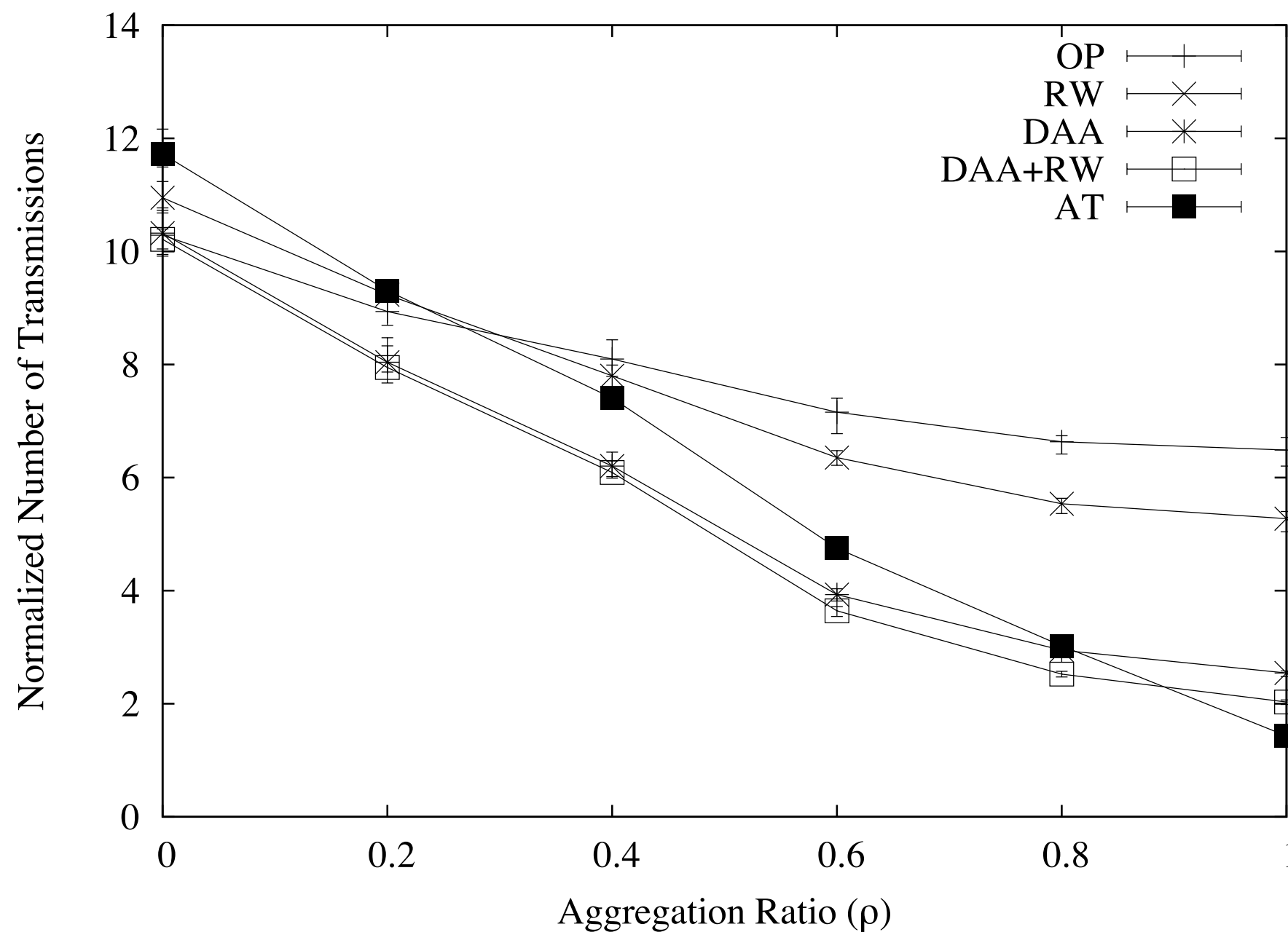
Simulation - Maximum Delay



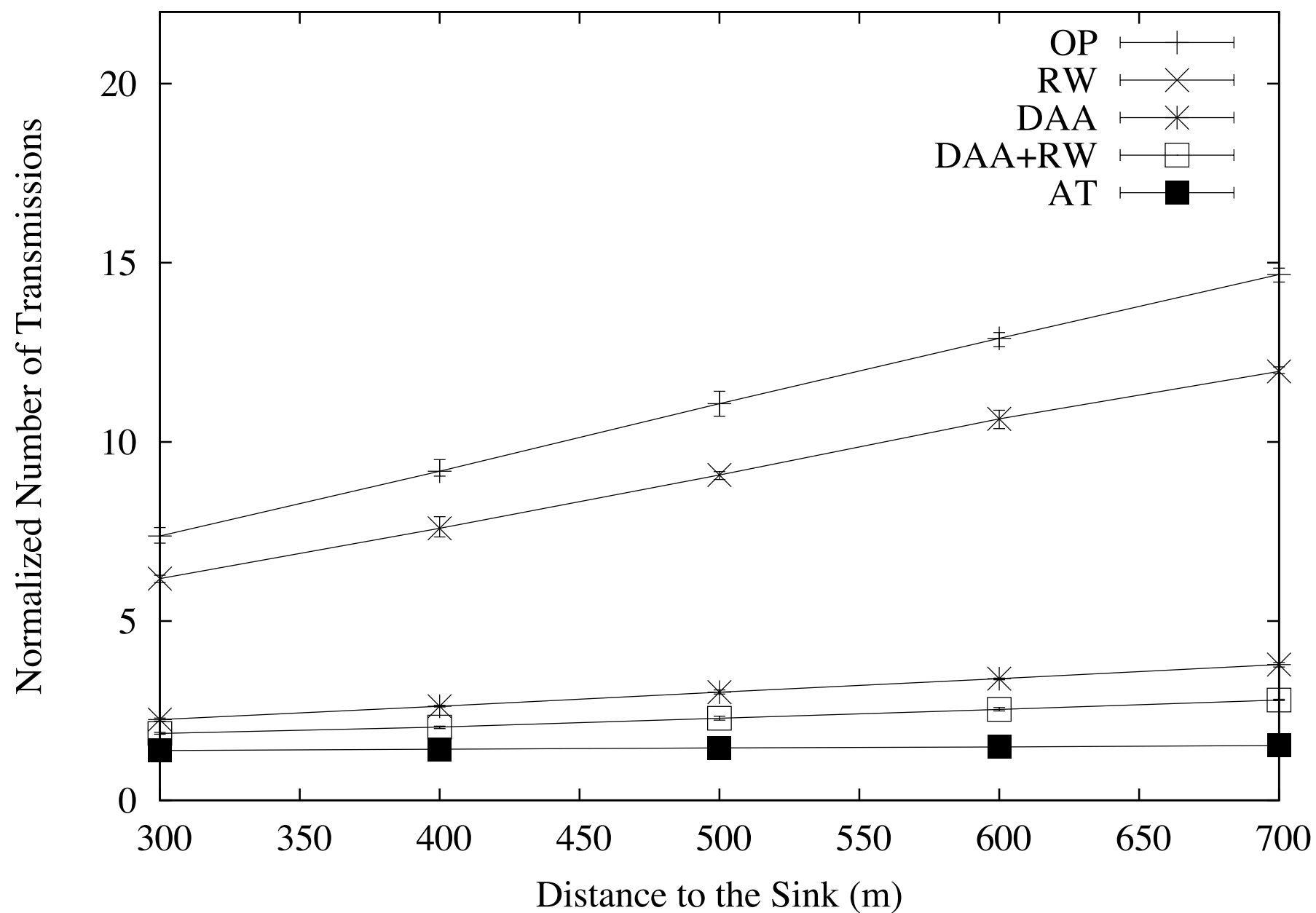
Simulation - Event Size



Simulation - Aggregation Ratio



Simulation - Distance to Sink

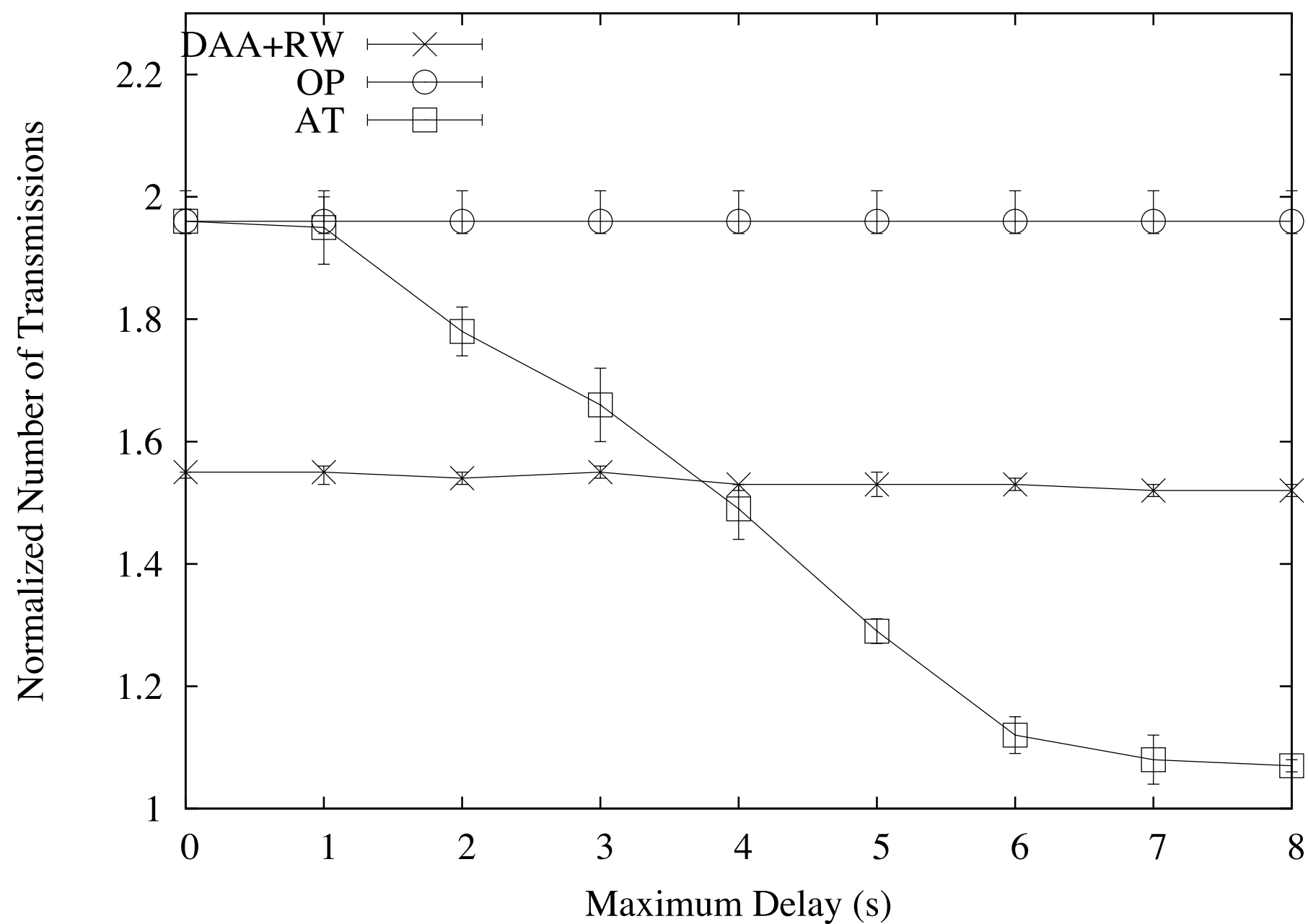


Experiment - Setup

- ❖ Kansei testbed
- ❖ 105 XSMs/Mica2 motes in a 15×7 grid network
- ❖ XSM at one corner act as sink



Experiment - Maximum Delay



Conclusion

- ❖ **Data-Aware Anycast for Spatial Convergence**
- ❖ **Randomized Waiting for Temporal Convergence**
- ❖ **Efficient aggregation without structure**
 - ❖ **73% load increase in comparison with opportunistic aggregation**
 - ❖ **Better performance than structured approach when aggregation is not perfect**