An Application-Specific Protocol Architecture for Wireless Microsensor Networks

EE360 Class Presentation

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Outline

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Characteristics of the underlying sensor network

- Dense
- Nearby nodes have correlated data
- Low energy per node
- Nodes always have data to send

Challenges in a Microsensor Network Deployment

- System lifetime
- Ease of Deployment
- Latency
- Quality

Previous work

- TDMA schemes
- Minimum transmission energy (MTE) routing
- Clustering approaches

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LEACH

Has the following phases

- Cluster Head (CH) Selection
- Cluster Formation
- Steady State Phase

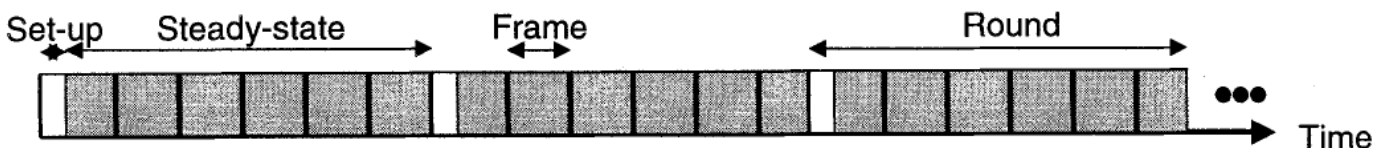

Figure: "Rounds" of cluster setup and data transfer

Cluster Head Formation (LEACH)

Designed mainly keeping in mind load balancing

- Node i elects itself with a probability P_i
- Expected number of cluster heads constant k
- At round $r+1$,

$$P_i = \begin{cases} \frac{k}{N - k(r \bmod N/k)} & \text{node } i \text{ wasn't CH in last } r \bmod N/k \text{ rounds} \\ 0 & \text{otherwise} \end{cases}$$

Cluster Head Formation (LEACH) contd..

- In case of unequal energy among nodes, one may choose

$$P_i = \min\left\{\frac{E_i}{E_{total}}k, 1\right\}$$

- k can be chosen based on N and the underlying energy model

Cluster Formation

- CH broadcasts an advertisement message
- Use of non persistent CSMA MAC
- Decision to join based on received signal strength
- CH sets up TDMA schedule for non CH nodes

Example pictures

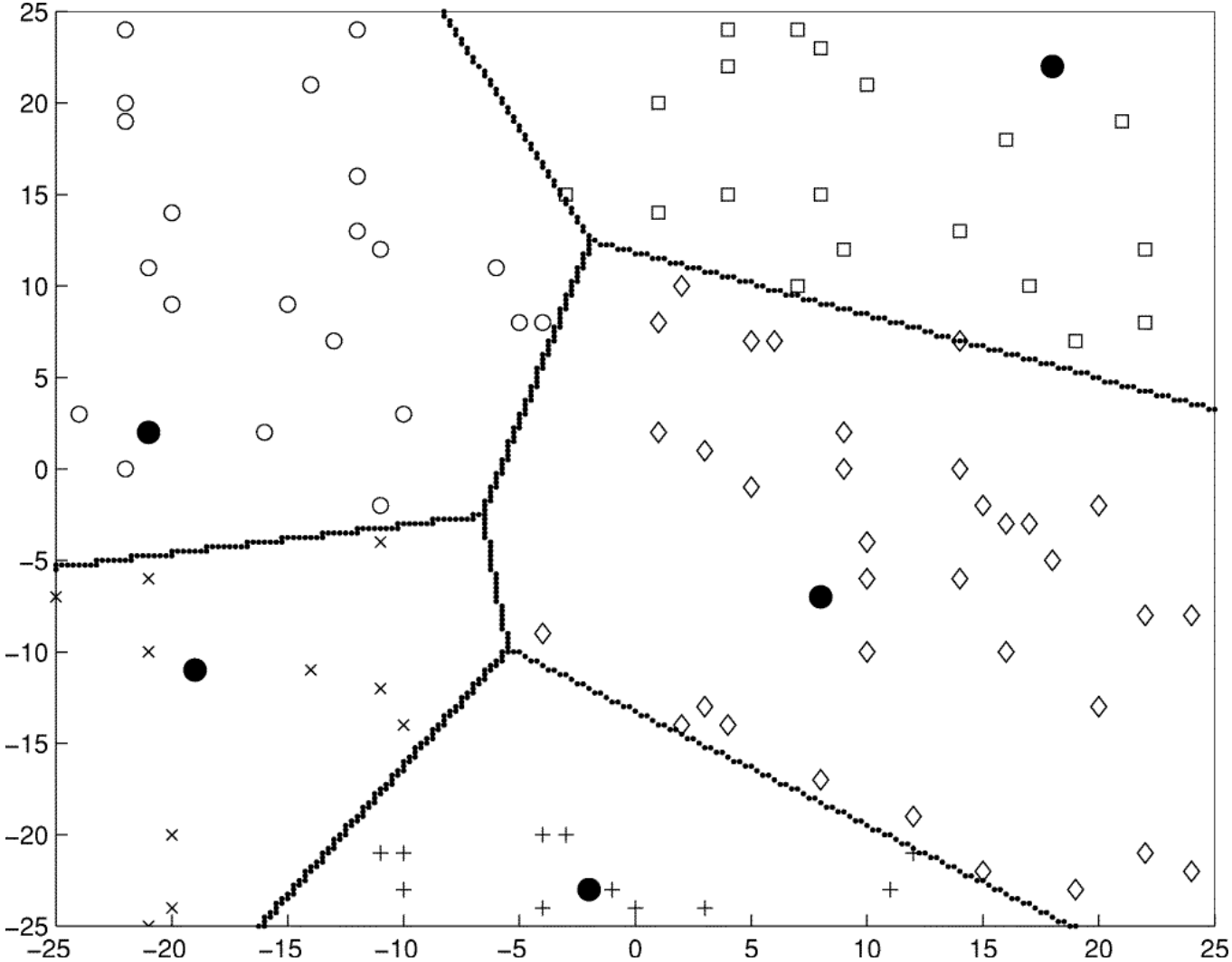

Figure: Cluster at one round

Example pictures

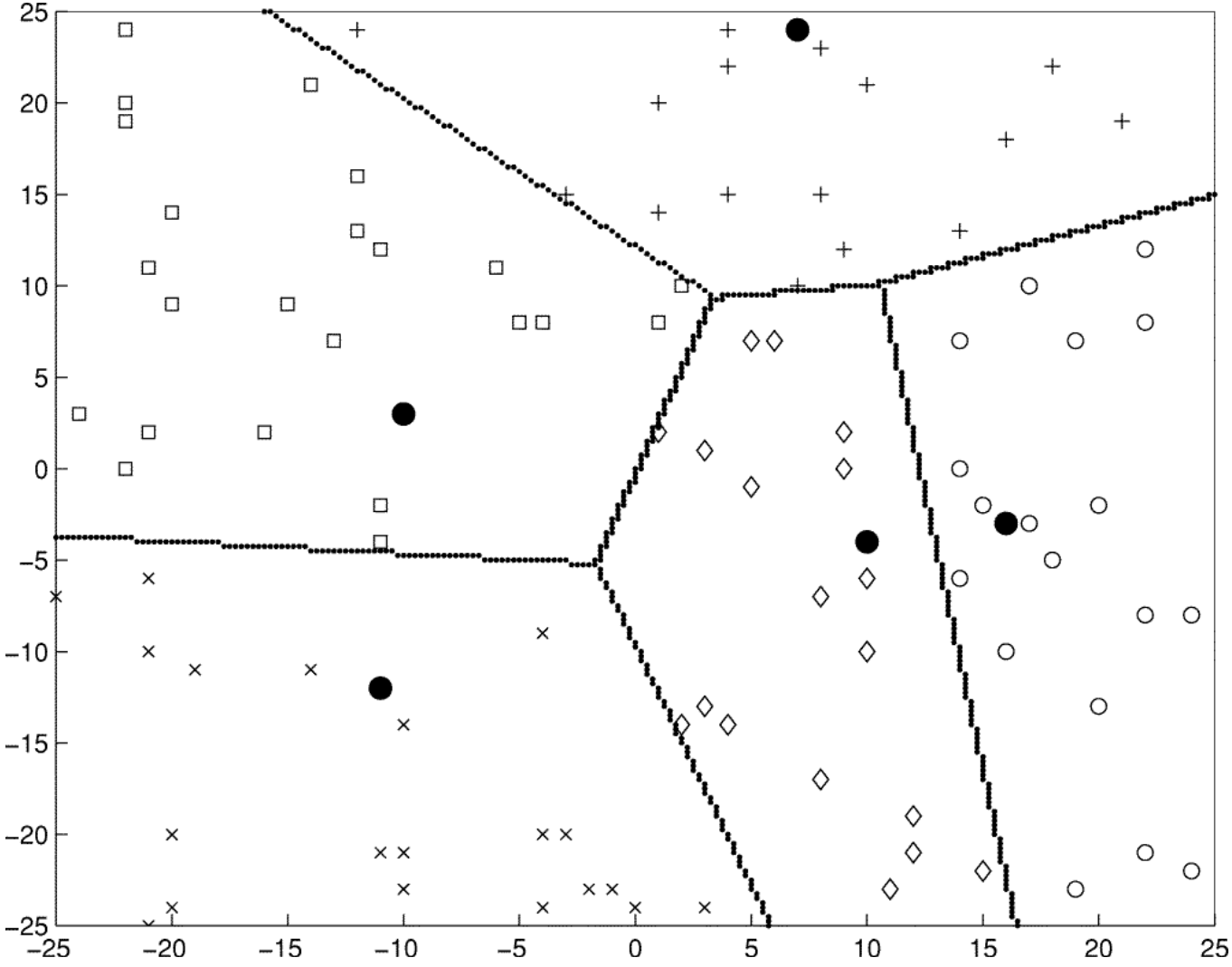

Figure: Cluster at next round

Steady State Phase

- Power control and sleep/wake operation
- Data Aggregation at CH
- Use of DSSS to reduce inter cluster interference
- Use of CSMA to further ensure non interference

A major shortcoming

Each node decides locally!

LEACH-C

- BS helps in the cluster setup
- Nodes send energy and location to BS
- BS broadcasts cluster and cluster heads
- Steady state phase is the same

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Analysis

- Analytic modelling is difficult
- Used network simulator ns to perform comparisons
- Comparison with MTE routing and static clustering

Details of simulated system

- 100 node system between $(0, 0)$ to $(100, 100)$
- BS at $(50, 175)$
- Bandwidth 1 MHz
- Each data message 500 b, header 25 b

Modelling the power consumption

- Free space models d^2 for intracluster communications
- d^4 path loss models for CH to BS communication
- Static energy and CSMA energy neglected
- Expected number of clusters per round 5

Modelling the power consumption (contd..)

- Every non CH node transmitter dissipates energy as

$$E_{tx} = \begin{cases} lE_{elec} + l\epsilon_{fs}d^2 & d < d_0 \\ lE_{elec} + l\epsilon_{mp}d^4 & d \geq d_0 \end{cases}$$

- Non CH receiver energy is

$$E_{rx} = lE_{elec}$$

- Every CH node dissipates energy as

$$E_{tx} = lE_{elec}(N/k - 1) + lE_{DA}N/k + lE_{elec} + l\epsilon_{mp}d^4$$

Performance metrics

- Data signals reaching the BS versus time
- Number of nodes alive versus time/data received at BS

Data signal versus time

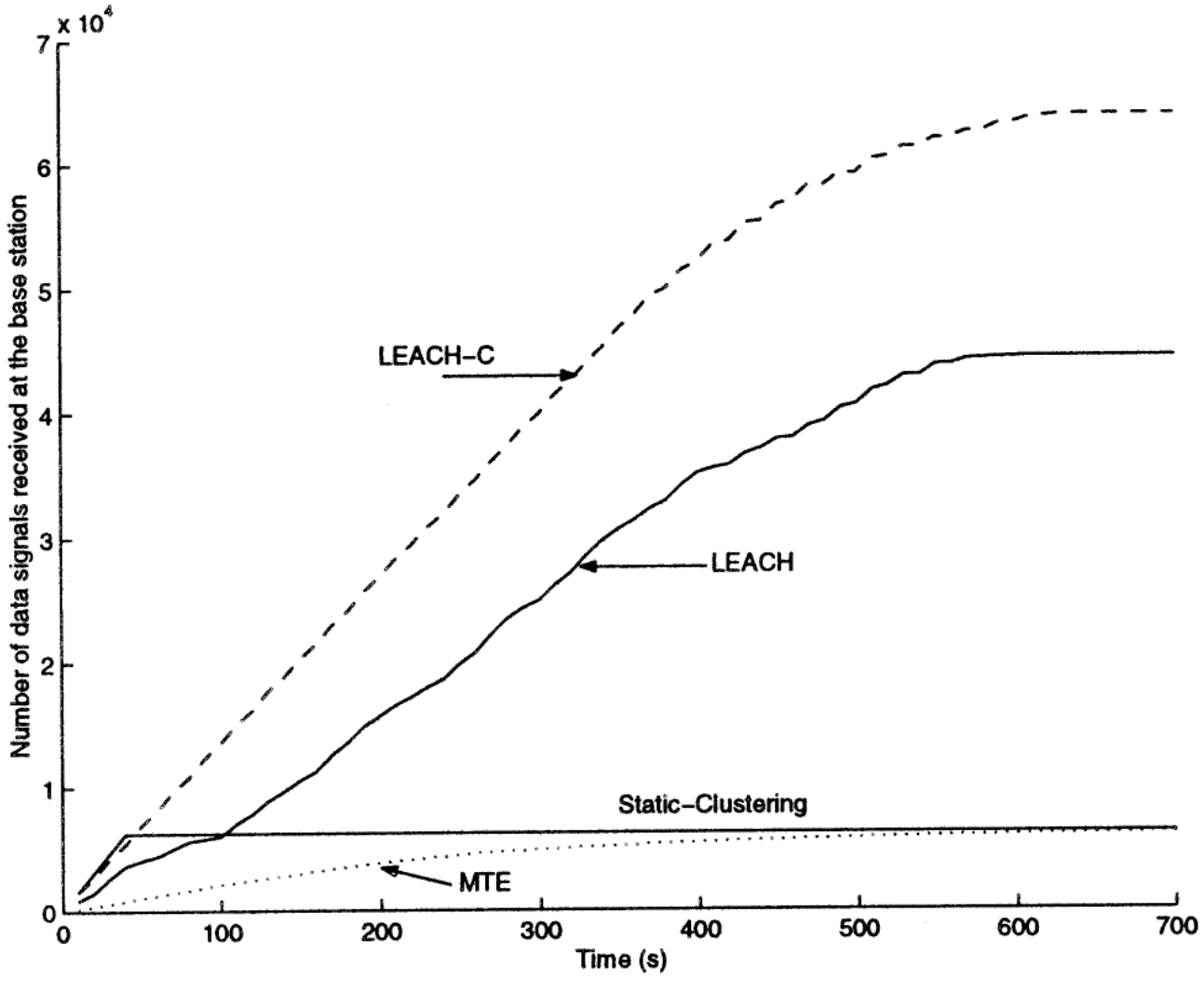

Figure: Data signals received at BS over time

Network Survivability over time

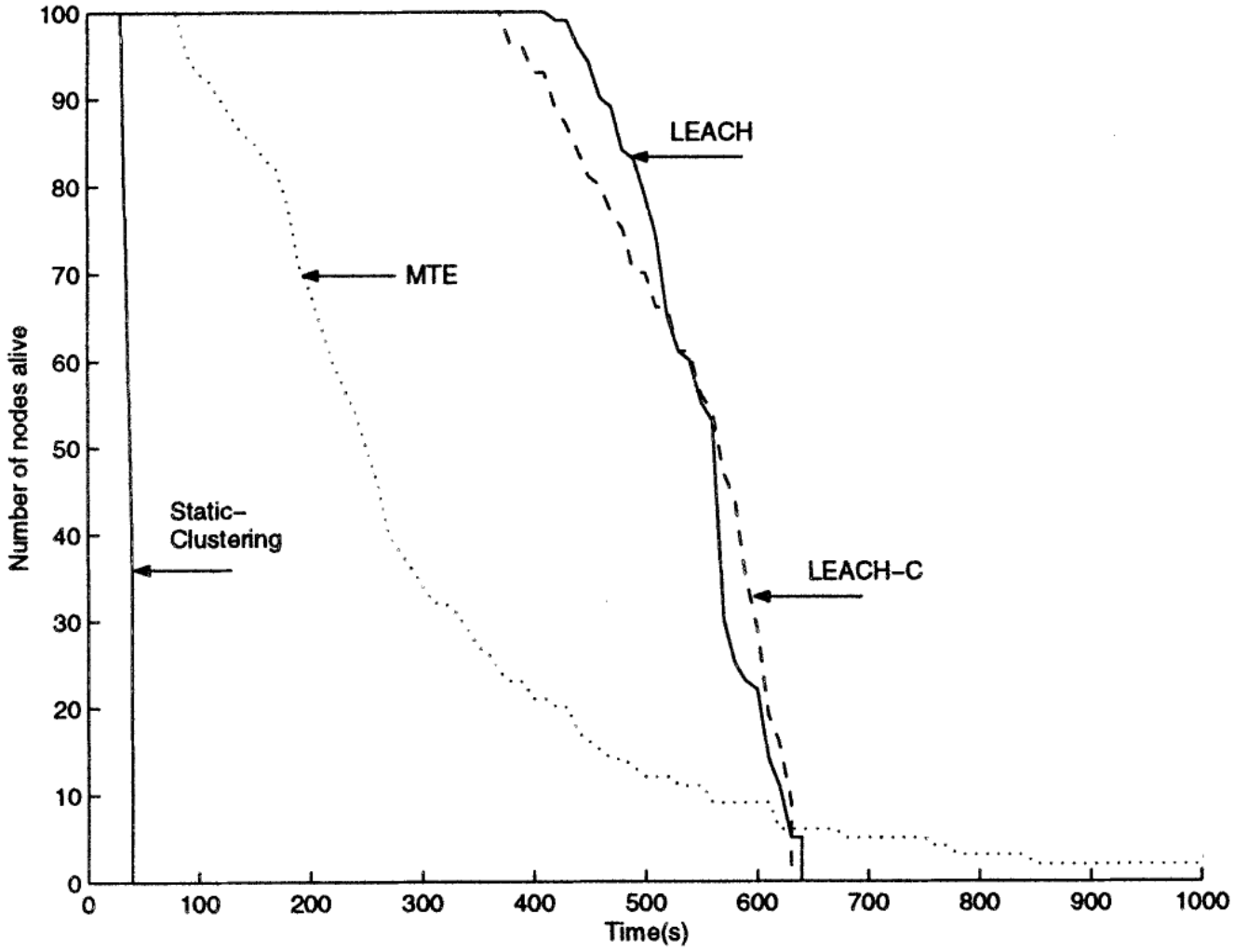

Figure: Number of surviving nodes alive with time

Network Survivability versus data transmitted

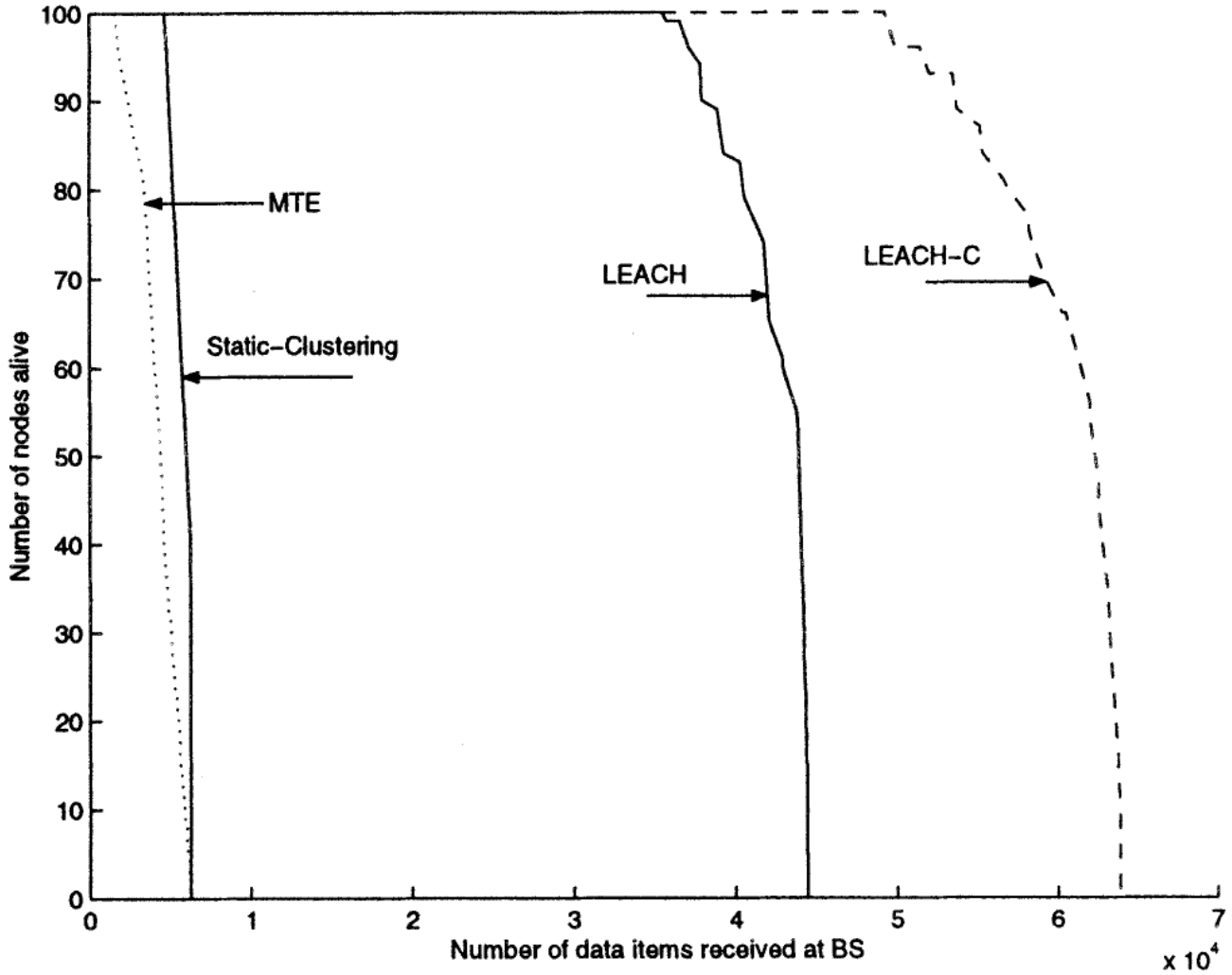

Figure: Number of surviving nodes alive versus data

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Some critical assumptions that went into design

- Always “on”
- Every node can talk to BS
- Correlation of information in a cluster

Conclusions

- Clustering
- Load balancing
- Energy efficiency

Conclusions

- Clustering
- Load balancing
- Energy efficiency

All of the above make this protocol suitable in a small ad hoc microsensor network deployment

Thank you!

Questions?