

Energy-Efficient Data Collection for Bluetooth-Based Sensor Networks

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Take Home Message

DCP:

- **D a C o l l e c t i o n P r o t o c o l – a communication protocol for sensor networks**
- Optimized for BT-equipped sensor nodes
- Builds a tree of clusters and collects data to a central base station
- Not affected by piconet or scatternet restrictions

Outline

- Problem Statement
- BT and Sensor Networks
- Data Collection Protocol (DCP)
 - Set-Up Phase
 - Steady-State Phase
- Simulation Results

Problem Statement

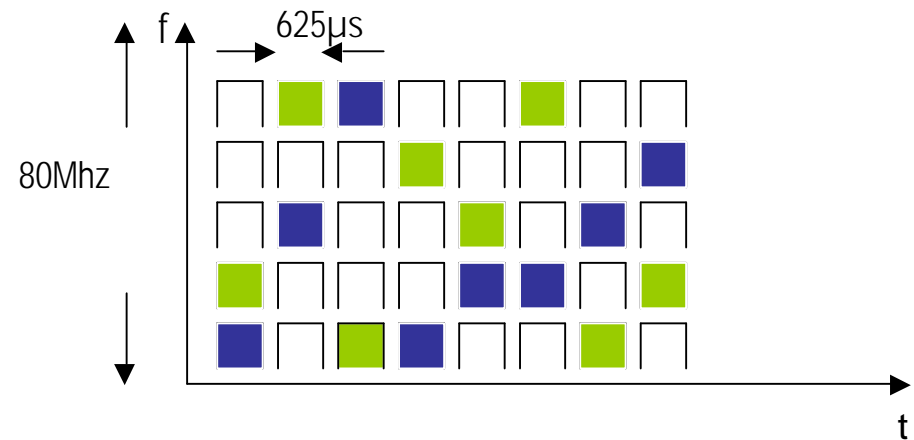
- **How to collect sensor data from a network with BT-equipped sensor nodes?**
 - scalable
 - robust
 - energy-efficient

Scenario: Flood Prevention



BT and Sensor Networks

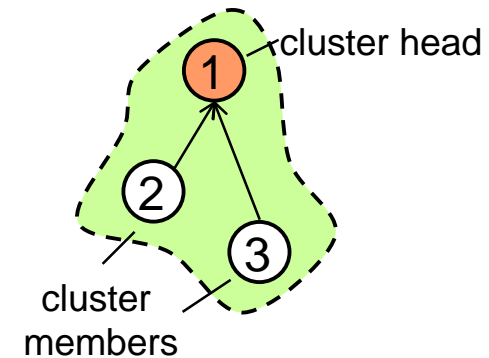
- ... a contradiction?
 - delay
 - energy consumption
 - network layer constraints
- ... but
 - cheap
 - available (!)
 - medium access



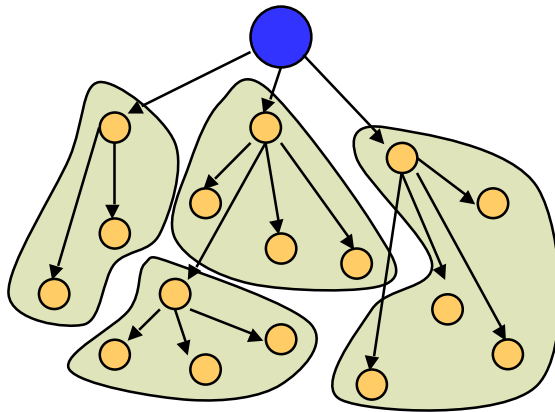
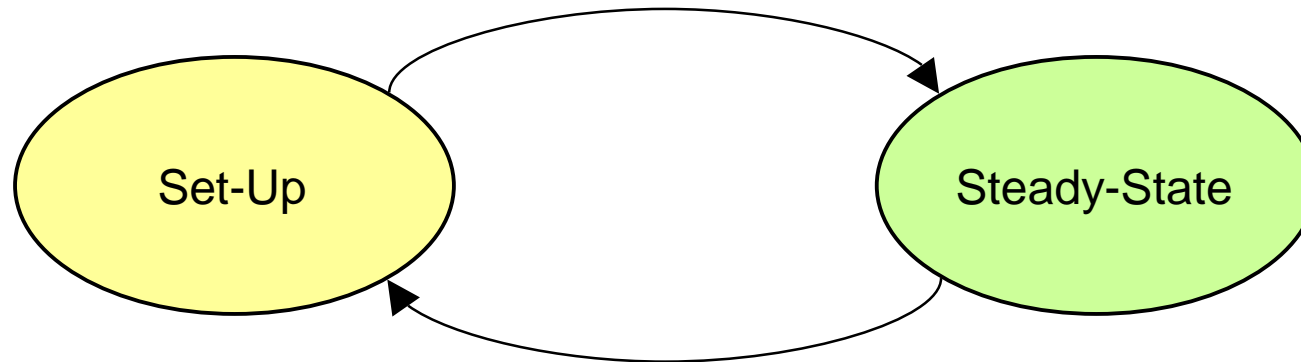
Thesis: Bluetooth is a qualified for **prototyping** sensor network applications!

Data Collection Protocol

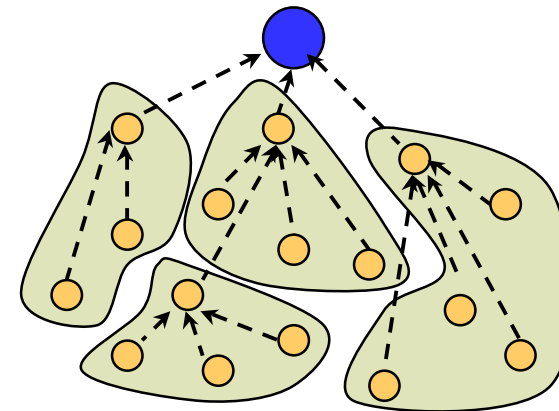
- Term „Data Collection“
- Cooperation Strategy: **Clustering**
 - Cluster Head, Cluster Member
- Periodic Cluster **Reorganization**
 - Energy consumption
 - Topology changes
- PFA = Packet Forward Address
- DCP does not maintain connections during steady-state (unlike scatternets!)



Data Collection Protocol – 2 Phases

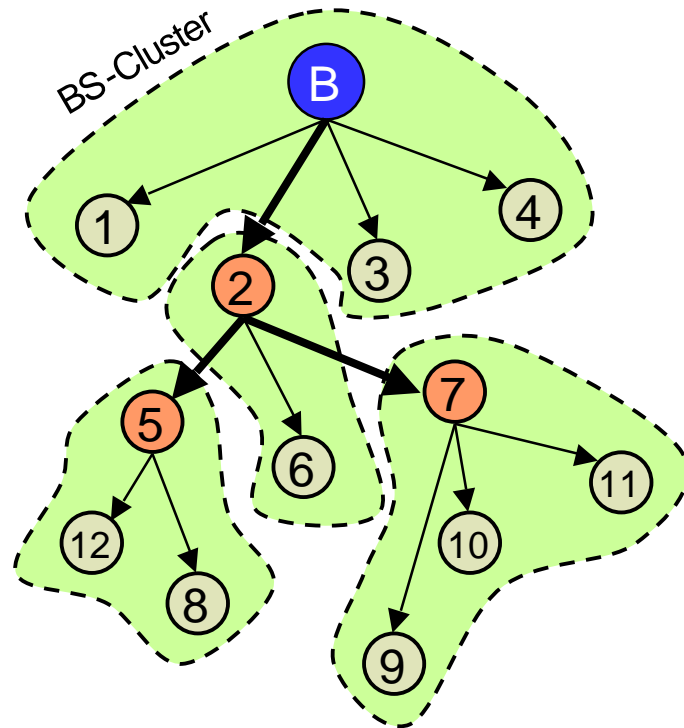


- Cluster Head Selection
- Cluster Formation
- PFA Delivery



Collection of Sensor Data

DCP – Set-Up-Phase (I)



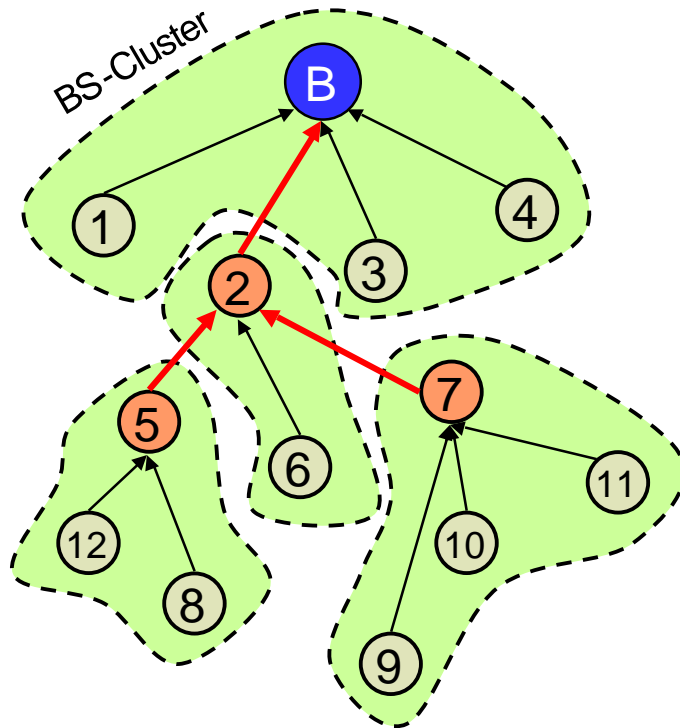
Abbreviations:

BS	= Base Station
CM	= Cluster Member
CH	= Cluster Head
PFA	= Packet Forward Address

1. Cluster Head Selection
 - randomly determined
2. Base Station Inquiry
 - detect CH and 1-hop-CM
3. Base Station transmits PFA
 - first CMs (1,3,4), then CHs (2)
4. Discovered nodes turn off inquiry scan
 - „invisible“ mode
5. 1-hop-distant CH inquiry
 - CM and CH discov. by BS are not detected due to disabled inq. scan
6. 1-hop-distant CH transmit PFA
 - first CMs (6), then CHs (5,7)

⋮

DCP – Steady-State-Phase



- CM transfer sensor data to CH
- CH preprocess sensor data (data compression/fusion)
- CH forward aggregated data to PFA/BS

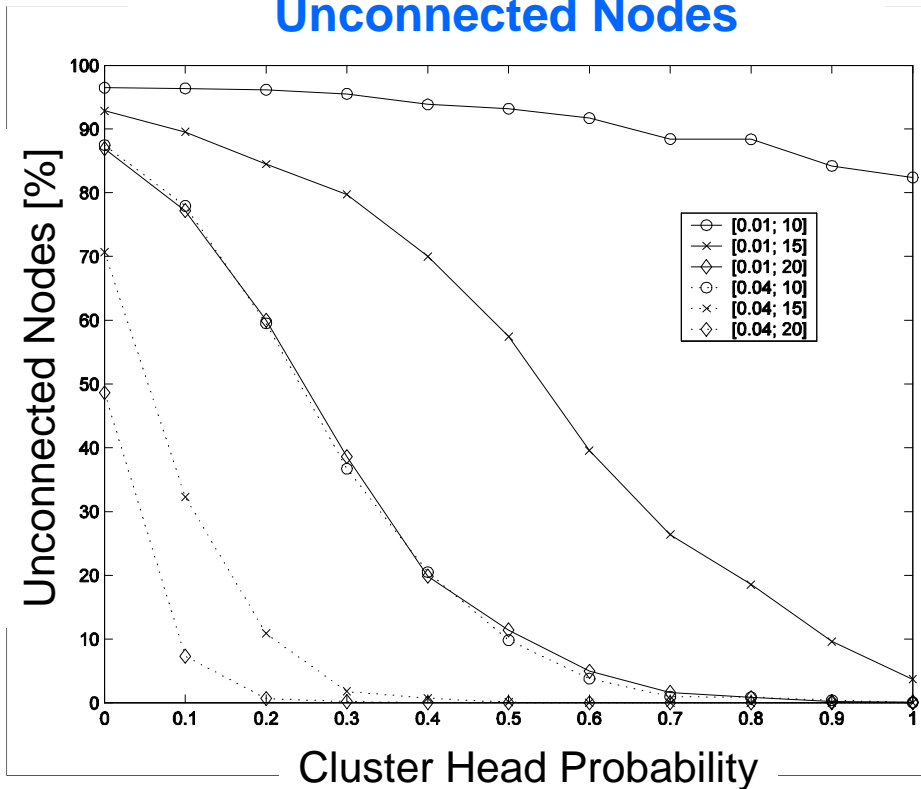
Nodes disconnect immediately (unlike scatternets)

- clusters are not limited to piconet size
- energy savings for low data rates
- reduced interference (How many Bluetooth piconets fit into a room?)

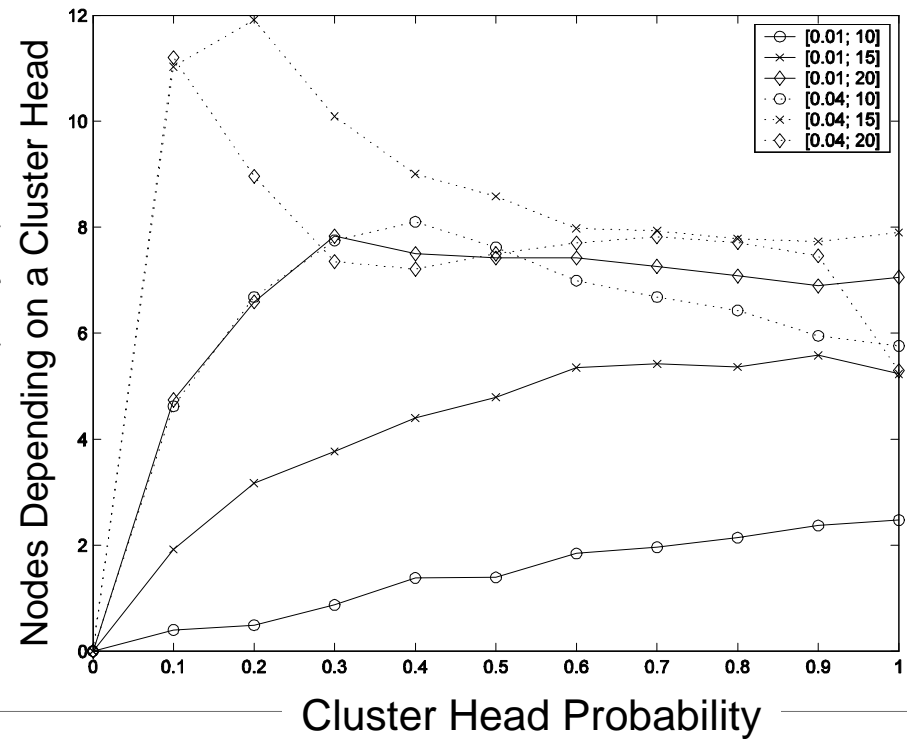
Simulation Results (I)

legend: [node density; node's transmission range]
2 simulation set-ups: 100m*100m with 100 nodes (node density 0.01)
50m*50m with 100 nodes (node density 0.04)

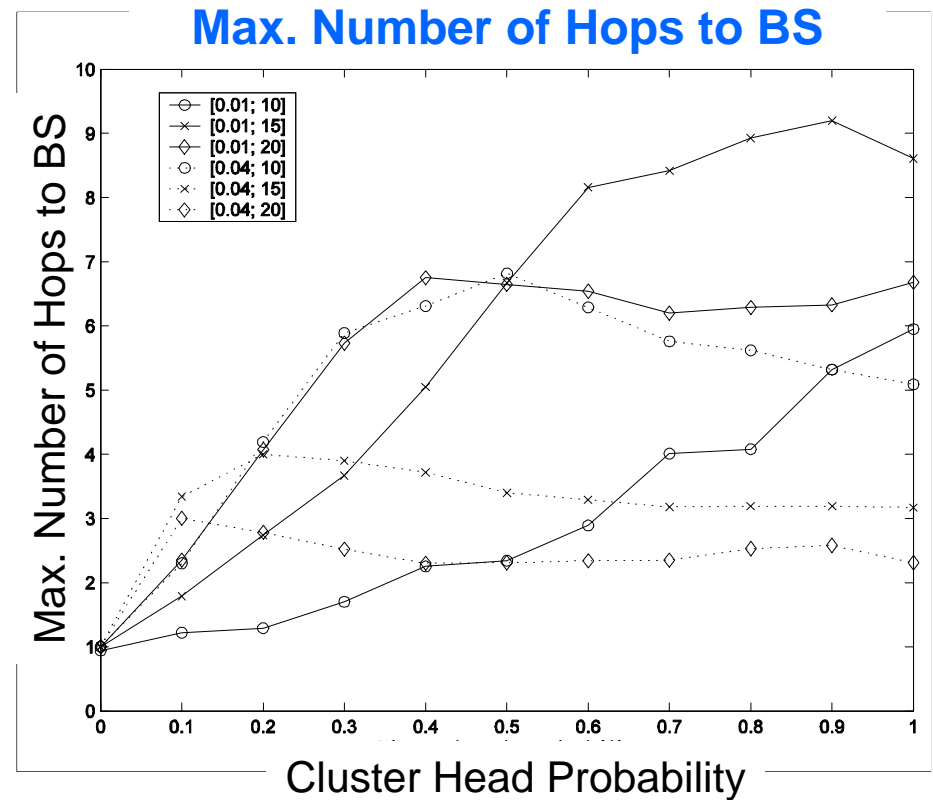
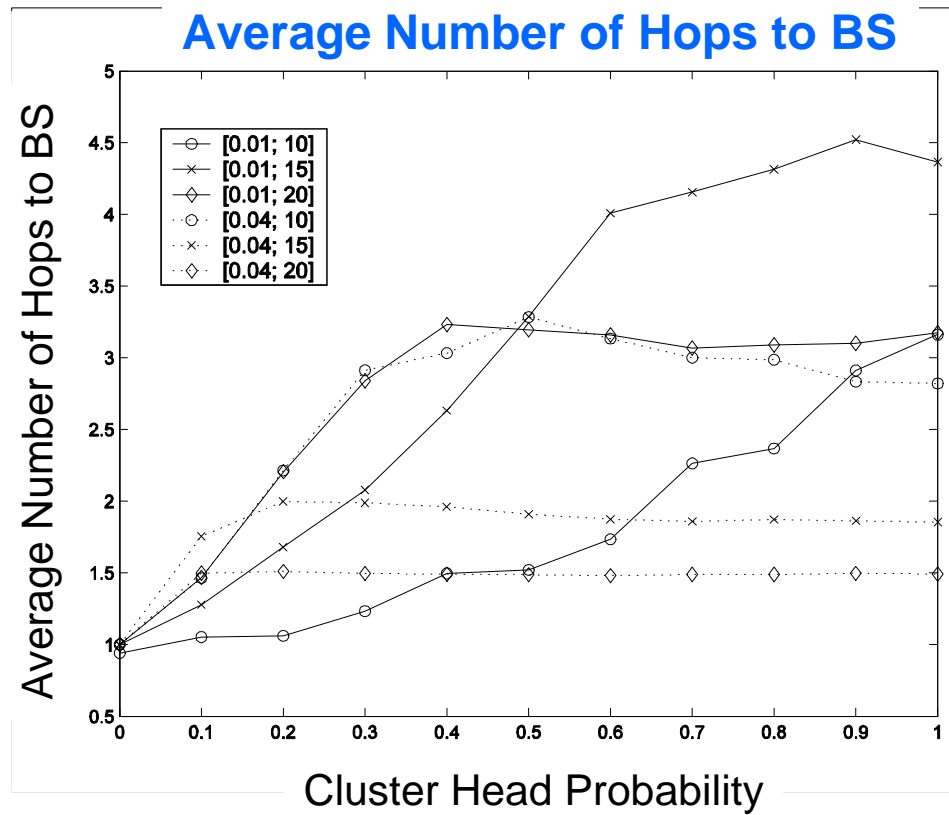
Unconnected Nodes



Number of Nodes Depending on a Cluster Head



Simulation Results (II)





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Thank You!

DCP – Set-Up-Phase (II)

- Synchronization of inquiry scans
 - Waiting time of cluster heads before inquiry

$$T_c = T_b \cdot r$$

T_c = waiting time

T_b = basic time

r = # of discovered CH not yet connected

Time for Connection Establishment, Data Transmission (DM1-packet), and Disconnection

Bluetooth-USB-Module (chip set)	Allnet 1572 (Broadcom)	Epox BT-DG02 (CSR)	Aiptek BT-USB (Transilica)
T_g (s)	4.40	4.46	4.47
ready after 6s	99 %	100 %	97 %

Basic Time

Outlook and Implementation