Energy-Efficient Data Collection for Bluetooth-Based Sensor Networks

Matthias Handy, *Jan Blumenthal*,
Dirk Timmermann

UNIVERSITÄT ROSTOCK

Institute of Applied Microelectronics and Computer Science

Take Home Message

DCP:

- **Data Collection Protocol – 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

3

Problem Statement

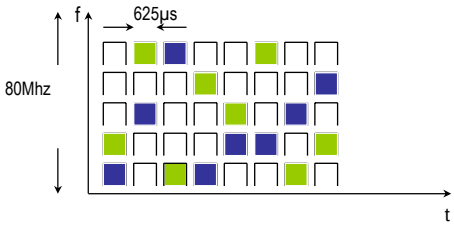
- **How to collect sensor data from a network with BT-equipped sensor nodes?**
  - scalable
  - robust
  - energy-efficient

Scenario: Flood Prevention

4

BT and Sensor Networks

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

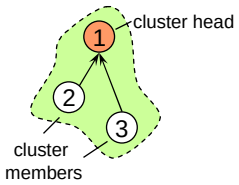


Thesis: Bluetooth is a qualified for **prototyping** sensor network applications!

5

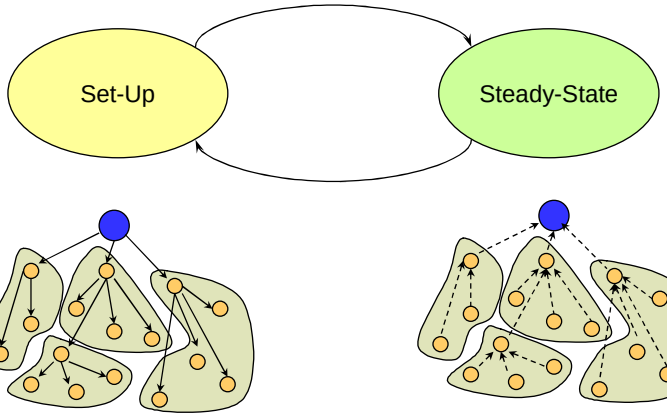
Data Collection Protocol

- 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!)



6

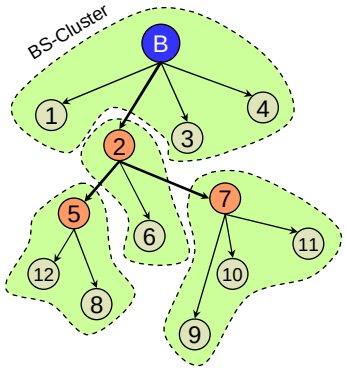
Data Collection Protocol – 2 Phases



- Cluster Head Selection
- Cluster Formation
- PFA Delivery

Collection of Sensor Data

DCP – Set-Up-Phase (I)

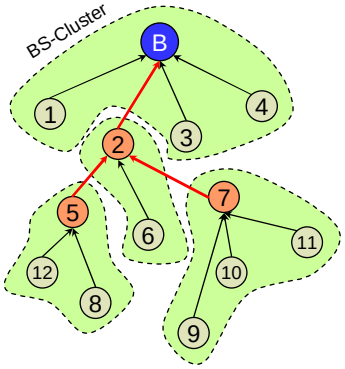


Abbrevations:

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
   - „invisibible“ 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)

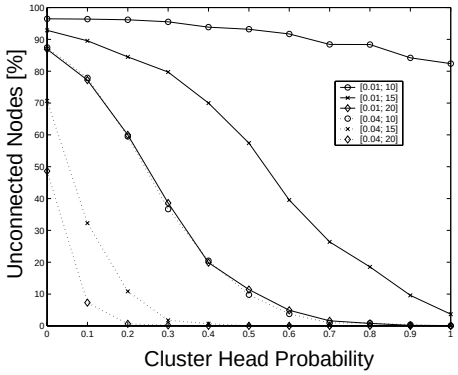
- clusters are not limited to piconet size
- energy savings for low data rates
- reduced interference (How many Bluetooth piconets fit into a room?)

9

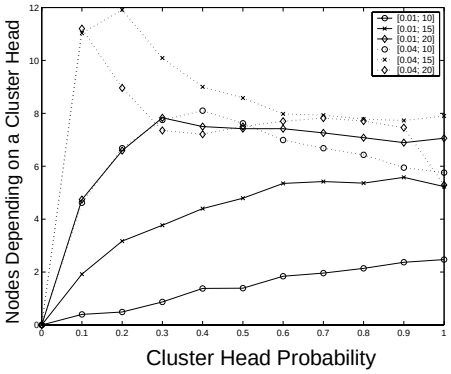
Simulation Results (I)

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)

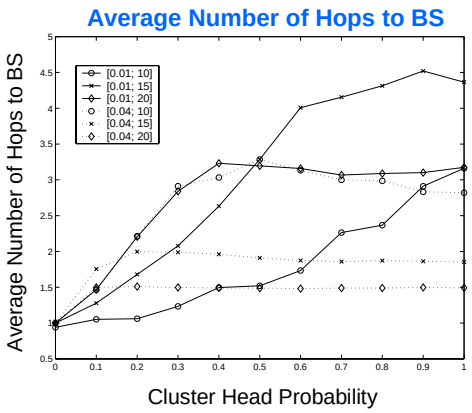
Unconnected Nodes

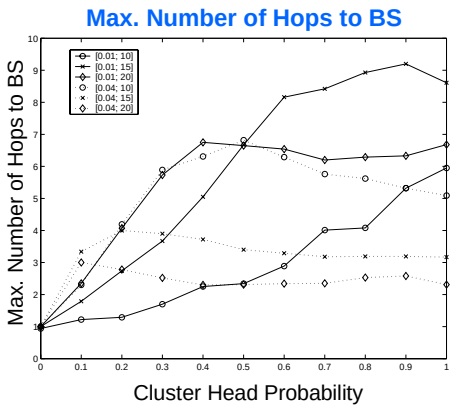


Number of Nodes Depending on a Cluster Head



Simulation Results (II)





11

Take Home Message

DCP:

- **Data Collection Protocol – 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

12

Thank You!

13

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

14

Outlook and Implementation

15