Multicasting in ad hoc networks: Energy efficient

Blerta Bishaj
bbishaj@cc.hut.fi
Overview

- Introduction
- Sources of power consumption
- Directional antennas
- TCP
- Broadcast and multicast tree construction
- Energy-efficient multicasting
- Conclusions
Introduction

- Multicasting, more complex in ad hoc networks
  - mobility
  - interference of wireless signals
  - broadcast communication
- Two types of multicasting protocols
  - source-based
  - core-based
- Energy is an issue
  - limited power supply
  - packets transceiving consumes power

Aim of power optimization
Increase the lifetime of the network
Introduction
Source-based protocols

- A tree for every source-group pair
- Bad scalability
Introduction
Core-based protocols

- Special nodes, **cores**, responsible for multicast data distribution
- Only **one multicast tree**
Sources of power consumption

- A mobile radio may be in three modes
  - transmit
  - receive
  - standby
- Power consumpt. for packet processing not analyzed
- As a transmitter,
  - send packets for control, request, response, data
  - send routed packets through this node
- As a receiver, receive
  - own packets (control and data)
  - packets to be forwarded
Directional antennas

- Energy focus in one direction
  - Increases spatial reuse
  - Provides farther transmission
  - Contributes in the wireless multicast advantage

The overall amt. of energy spent is reduced

- Other advantages:
  - Higher netw. capacity (more simult. conn., and fewer hops)
  - Improved connectivity (longer range)
  - Reduced eavesdropping
TCP

- TCP uses **timeouts** and **duplicate ACKs** to indicate **congestion**
- The wireless connections
  - high error rates, **retransmissions at the data link layer**
  - **packets** and **ACKs** are **delayed**
  - **transmission slows down**
  - packets are **retransmitted** (extra **energy spent** at the sender and at the intermediary nodes)

Possible solutions **instead of TCP counters**
- Explicit Link Failure Notification (**ELFN**)
- Explicit Congestion Notification (**ECN**)
The mobility of the nodes

- packets arrive along **different routes**
- **duplicate ACKs** => retransmission => throughput reduced
- **increased energy consumption**

Possible solution

- **retransmit** the packet
- **not decrease traffic**
Broadcast and multicast tree construction
The wireless multicast advantage

- The power required to transmit to the farthest node

\[ P_{i,(j,k)} = \max(P_{ij}, P_{ik}) \]
Objective: minimum-power tree

- Nodes added one at a time
- Next node determined by least incremental power
- Considers the wireless multicast advantage
- MIP is obtained from pruning the undesired branches
To construct the tree:
- assumption of an **underlying unicast alg.** – provides min distance unicast paths
- **superposition of the best unicast paths** to the destinations

The algorithm
- **fails** to consider the **wireless multicast advantage**
- **MLU** obtained by the superposition of only the routes to the desired destination nodes
To construct the tree:
- Associate a link power-cost to each pair of nodes

The algorithm
- **fails** to consider the wireless multicast advantage
- MLU obtained by the **pruning** the undesired nodes from the tree
Energy-efficient multicasting for reliable data transfer

1. Energy-Efficient Reliable Broadcast and Multicast Protocols
2. A Distributed Power-Aware Multicast Routing Protocol
4. Energy-Efficient Cluster Adaptation of Multicast Protocol
1. Energy-Efficient Reliable Broadcast and Multicast Protocols

- **Reliability** means that retransmission might be needed
- **Packet-error probability** is considered
- BIP, BLU, BLiMST, MIP, MLU, and MLiMST can be modified to consider \( E_{ij}(\text{reliable}) \)

\[
E_{ij}(\text{reliable}) = E_{ij} / (1 - p_{ij})
\]

\( p_{ij} \) – packet-error probability
\( 1 / (1 - p_{ij}) \) – the expected rate of retransmission from node I to node j
2. A Distributed Power-Aware Multicast Routing Protocol

- An **underlying unicast protocol** implied
- Two possible **metrics** for **minimal node-to-node path**

\[ C = \frac{P_{1,2} + P_{2,3} + \ldots + P_{j-1,j}}{\min(K_1, K_2, \ldots, K_j)} \]

\[ D_{i,j} = \frac{P_{i,j}}{\min(K_i, K_j)} \]

Then, \( D \) would be

\[ D = D_{0,1} + D_{1,2} + \ldots + D_{n-1,n} \]

\( K_i \) – no of transceivers at node \( i \)

\( P_{ij} \) – power needed for transmitting a packet from node \( i \) to \( j \)

- Two phases:
  - Minimum Energy Consumed per Packet (MECP)
  - Minimum Maximum Node Cost (MMNC)

- MECP considers the energy consumption for packet transmission along the path

- MMNC considers the power level at the nodes along the path

- The two phases are alternated periodically
4. Energy-Efficient Cluster Adaptation of Multicast Protocol

- Proposed for cluster-based schemes
- Each cluster has a head
- The fewer cluster heads, the more energy spent by head to reach distant nodes
- The more cluster heads, the more energy spent for the overhead at the supernode level

Some balance is needed

- Nodes start out as cluster heads
- Information exchanged, they join clusters
- Nodes become head of cluster in turns (so some nodes do not power out fast)
Conclusions

- The wireless multicast advantage should be exploited.
- Other efforts also combined (TCP, directional antennas).
- The ultimate purpose – prolonging the lifetime of the network.