Optimized Stateless Broadcasting in Wireless Multi-hop Networks

IEEE INFOCOM 2006
Presented by Chun-Hung Liao
2006/12/22
Outline

- Introduction
- Related work
- Stateful & Stateless protocol
- Dynamic Delayed Broadcasting Protocol
  - DDB 1 for Minimizing the Number or Transmission
  - DDB 2 for Maximizing Network Lifetime
- Simulation
- Conclusion
Introduction

- Broadcasting is most simply and commonly realized by flooding whereby nodes broadcasts each received packet exactly once.

- Flooding generates a large number of redundant transmissions.

- This excessive broadcasting causes heavy contention and collisions, commonly referred to as the broadcasting storm problem.
Introduction

- Broadcasting protocol
  - Stateful
    - Barely affected by high traffic loads and collisions, but their performance suffers significantly in highly dynamic networks as the frequent topology changes.
  - Stateless
    - Do not require any knowledge of the neighborhood, but they perform well in specific scenarios but poorly in others, e.g., for varying node densities and traffic loads.
Introduction

- In this paper, the proposed protocol DDB (Dynamic Delayed Broadcasting) is **stateless**.

- Using Dynamic Forwarding Delay function (DFD) to allow nodes make locally optimal rebroadcasting decisions.
Related work

- Many broadcasting protocols have been proposed in order to cope with the broadcasting storm problem
  - Probability-based
  - Location-based
  - Neighbor-designated
  - Self-pruning
  - Energy-efficient
Dynamic Delayed Broadcasting Protocol

- **DDB 1** for Minimizing the Number or Transmission
  - Using addition area coverage
  - Using signal strength

- **DDB 2** for Maximizing Network Lifetime
Dynamic Delayed Broadcasting Protocol

- DDB 1 with additional area coverage (AC)

\[ AC(d) = 2 \left( \int_{-\frac{d}{2}}^{1} \sqrt{1 - x^2} \, dx - \int_{-\frac{d}{2}}^{-d+1} \sqrt{1 - (x+d)^2} \, dx \right) \]

which immediately yields

\[ AC(d) = \frac{d}{2} \sqrt{4 - d^2} + 2 \arcsin \left( \frac{d}{2} \right) \quad (1) \]
Dynamic Delayed Broadcasting Protocol

- **DDB 1 with addition area coverage**
  - AC(d) is maximal if node B is located just the boundary of the transmission range of node A, i.e. if d = 1.
  
  \[ AC_{MAX} = \left( \frac{\sqrt{3}}{2} + \frac{\pi}{3} \right) \approx 1.91 \]

  - Depending on AC(d), the node introduces a delay before relaying the packet.

  \[ Add\_Delay = Max\_Delay \cdot \sqrt{\frac{e - e\left(\frac{AC}{1.91}\right)}{e - 1}} \quad (2) \]

  - A rebroadcasting threshold(RT) also may be zero. If AC < RT, The node doesn’t rebroadcast a packet.
Dynamic Delayed Broadcasting Protocol

- DDB 1 with addition area coverage

Fig. 2 Delay introduced by the DFD function
Dynamic Delayed Broadcasting Protocol

- Illustrating Example of DDB 1 with addition area coverage
Dynamic Delayed Broadcasting Protocol

- DDB 1 with signal strength
  - Using the incoming signal strength as input to the DFD function.

\[
\text{Add\_Delay} = \text{Max\_Delay} \cdot \sqrt{\frac{\alpha \sqrt{10(S_r - P_r)}}{e - 1}}
\]  

\( \alpha \): an attenuation factor  
\( S_r \): a receiver sensitivity  
\( P_r \): a receiver power measured in dBm
Dynamic Delayed Broadcasting Protocol

- DDB 2 for Maximizing Network Lifetime
  - We may expect that the traffic load is also uniformly distributed over all nodes, and thus the battery will deplete roughly at the same time at all nodes.

\[
\text{Add\_Delay} = \text{Max\_Delay} \cdot \sqrt{\frac{e - e^{EB}}{e - 1}} \quad (4)
\]

E_B is the remaining battery power of a node as percentage of the total battery capacity.
Dynamic Delayed Broadcasting Protocol

- Optimizations
  - First Always Forwarding Policy
    - Able to cope with varying network conditions such as node density and traffic load.
  - Cross-Layer Information
    - DDB should be able to access packets on the MAC layer, more precisely in the queue of the wireless interface.
Simulation

- DDB Comparison with
  - LBP: location-based broadcasting protocol
  - MPR: multipoint relaying
  - Simple flooding

- Only vary one of the important network parameters, i.e., density, mobility, and congestion.

- Simulation parameters
  - Max_Delay set to 2 ms
  - RT set to 40% of the maximal additional covered area
Simulation

DDB outperforms other protocols.

1000 nodes

DDB 1
Stateful protocols performs well. 80 nodes, each with 19 neighbors
Stateless protocols are unaffected and the performance remains constant independent of the mobility.
Simulation
Conclusion

- DDB still performs well under heavy traffic and high load density, whereas other protocols’ performance degrade, such as LBP.

- DDB is stateless, its performance is completely unaffected in highly dynamic networks.

- The biggest advantage of DDB is its simplicity and economical use of network resource because no control messages are transmitted.