Priority Forwarding: An Efficient Flooding Technique for Wireless Ad Hoc Networks

Kihwan Kim

POS Members: Wallapak Tavanapong (Major Professor) Shashi K. Gadia Daniel Berleant

Outline

- Introduction
- Motivation & Challenge
- Existing works
- Proposed work
- Performance Study
- Conclusion & Future Work
Introduction

- Wireless ad hoc network
  - No fixed infrastructure
  - Some hosts need to forward packets
  - Hosts can move freely through the network area.

Flooding (Broadcast)
- A host sends a packet to all other hosts in the networks
Outline

- Introduction
- **Motivation & Challenge**
- Existing Works
- Proposed Works
- Performance Study
- Conclusion & Future Work

Motivation

- Simple flooding requires every host to forward a packets.
- Can we reduce the number of nodes which is involved in forwarding a packet?
Challenges

- Reachability problem
  - Every host must receive a packet from source

- Network latency Problem
  - Packet propagate as soon as possible

Outline

- Introduction
- Motivation & Challenge
- **Existing Works**
- Proposed Work
- Performance Study
- Conclusion & Future Work
Existing Works

- Simple approaches
  - Probability based schemes
  - Count based scheme
- Location based approaches
  - Area based scheme
  - Angle based scheme
- Neighbor information based schemes
  - 1-hop neighbor information scheme
  - 2+hop neighbor information scheme

Existing Works (Simple Approach)

- Probabilistic Scheme [Tseng 99]
  - Hosts forwards packets with certain probability
  - 100% probability is same as flooding
  - PS Achieves reducing the number of nodes which is involved in forwarding a packet
  - PS makes reachability problem
Existing Works
(Simple Approach)

- **Counter-Based Scheme** [Tseng 99]
  - Use waiting time to observe duplicate packets
  - A host drops a packet if it receives the same packet more times than a predefined threshold during the waiting time.
  - CS makes network reachability & latency problem

![Diagram with threshold = 2]

Existing Works
(Location Based Approach)

**Area-Based Scheme**
- Calculate additional coverage
- If the additional coverage is small, the host drops the packet.
- AS makes Reachability problem

![Diagram with A, S, C, O, B]
Existing Works
(Location Based Approach)

- Distance based defer (waiting) time & Angle based

Assumptions
- Every host knows its position and the sender's position
- Does not require neighbor information

Idea
- Set the waiting time inverse proportional to the distance between a sender and a receiver
- Use angle to get high reachability

Existing Works
(Location Based Approach)

- Distance-base waiting time
  - Shorter distance → Larger waiting time
    - Distance : between sender and receiver
  - Waiting Time
    - Waiting time = Max_wait_Time * ( R^n - ||SN|| ) / R 
    - where R is the transmission Radius

N2 has a shorter defer time than N1 since N1 covers more area
Existing Works
(Location Based Approach)

- Angle-base retransmission policy

During the waiting time, N may receive duplicate packets.
If the combined angle computed using the senders' position of the duplicate packets is 360 degree, N doesn't need to rebroadcast message.

Existing Works
(Neighbor Information Approach)

- Self Pruning scheme (1-hop neighbor) [Laouiti 02]
  - Sender includes its 1-hop neighbors in a packet header.
  - Receiver drops a packet if all of its neighbors receive a packet.

```
A.IsForward( N, P )   /* P is packet */
If (N-P == {}) then Drop a packet
else A.Send(N)
```

```
S. Send(N)   /* N is Neighbor Set */
P ← {A, B, C}
Send P;
```

S’s neighbor = {A, B, C}
A’s neighbor = {B}
Existing Works (Neighbor Information Approach)

- OLSR (Optimized Link State Routing) scheme (2-hop neighbor) [Laouiti 02]
  - Sender determines which of its 1-hop neighbors should rebroadcast
  - 2-hop neighbor knowledge is required (Heavy computation)
  - No waiting time is used
  - Choosing relay set is NP-hard

Reference: www.snrc.uow.edu.au/~justin/ICON03.ppt
Existing Works
(Neighbor Information Approach)

Relays = \{B,D\}

Reference: www.snrc.uow.edu.au/~justin/ICON03.ppt

Outline

- Introduction
- Motivation
- Existing work
- Proposed work
- Performance Study
- Conclusion & Future Work
Assumptions for the Proposed Work

- A host has a global positioning system
- A host maintains 1-hop neighbor information
- A host uses waiting time
- Each host has the same transmission range (R)

Proposed Work

- Dynamic waiting time
  - Receiver sets its waiting time based on the distance between the sender and itself
    - Shorter distance → Larger waiting time
  - \[ W = \text{Max}_W \times \frac{R - \text{dist}(B, S)}{R} \]
Proposed Work

- Dynamic waiting time (cont’)
  - The host adjusts its waiting time dynamically when it receives duplicate packets from other hosts

  \[ W = \max \left( W, \text{Max}_W \left( \frac{R - \text{dist}(B, A)}{R} \right) \right) - T \]

  B’s new waiting time after receiving a duplicate packet from A at time \( T \)

Proposed Work

- Priority Forwarding
  - Sender determines forwarding priority of its neighbors based on distances

  Priority = (A, B, C)
Proposed Work

**Algorithm**

When a host receives a packet

Procedure Forwarding (Neighbor, Packet)
If (All neighbors receive packet)
    Drop the packet; Return;
If (First Priority)
    Determine the priority of my neighbors
    Forward the packet; Return;
Else
    Set waiting time
    Update Neighbor Set

**Example**

1. S forwards a packet
   priority = (A, B, C)
2. A, B, and C receive the packet
3. A’s neighbor = {B, C, D, S}
   A forwards the packet with
   priority = (C, D, B)
4. B extends its wait time and
   changes its priority after
   receiving the packet from A
   B’s neighbor = {A, F, S, C}
   priority = (C, F)
Outline

- Introduction
- Motivation
- Existing Works
- Proposed Work
- **Performance Study**
- Conclusion & Future Work

Performance Study

- **Evaluation Criteria**
  - Retransmission rate
    - \[ R = \frac{\text{Total number of forwarding hosts}}{\text{Total number of hosts}} \]
  - Network Latency
    - \[ L = \text{Time when the last host receiving the packet} - \text{Time of first host sending the packet} \]
Performance Study

- Simulation Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Default</th>
<th>Variation</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network Area</td>
<td>500 x 500</td>
<td>10^4 - 10^6</td>
<td>meter^2</td>
</tr>
<tr>
<td>Host Density</td>
<td>0.05</td>
<td>0.01 - 0.1</td>
<td>host/meter^2</td>
</tr>
<tr>
<td>Transmission Radius</td>
<td>10</td>
<td>5 - 15</td>
<td>meter</td>
</tr>
</tbody>
</table>

Performance Study

- Compared methods
  - Simple flooding (0-hop neighbor info.)
  - Self Pruning (1-hop neighbor info.)
  - DBDT-ABS (Distance Based Defer Time & Angle Base Scheme)
  - Priority Forwarding (1-hop neighbor info.)
Performance Study

- Impact of Host Density

- Impact of Network Area on Latency
Performance Study

- Impact of Transmission Radius

Discussion

- Mobility Problem

S’s neighbor at Time T
= \{A, B, C\}

S’s neighbor at Time T + \alpha
= \{B, C\}
Discussion

- Handling Mobility (Conservative Circle)

\[
\text{Conservative Radius} = R - 2(T \times \text{Max Speed})
\]

Conclusion

- Priority forwarding uses dynamic waiting time setting & priority
- Priority forwarding achieves low retransmission rate
  - As much as 80% lower transmission rate compared with simple flooding
  - As much as 60% lower transmission rate compared with the best existing technique in our study
- In the best case, Priority forwarding has network latency of only \(\frac{1}{4}\) of that of DBDT-ABS
Thank you!!

Existing Works
(Location Based Approach)

- How to compute the angle information?

\[
\angle CNS = \cos^{-1}\left( \frac{\mathbf{SN} \cdot \mathbf{NC}}{\|\mathbf{RN}\| \cdot \|\mathbf{RC}\|} \right)
\]

\[
\angle ANS = \cos^{-1}\left( \frac{2 \cdot R^2 - \|\mathbf{SN}\|}{2 \cdot \|\mathbf{SN}\| \cdot R} \right)
\]

\[\alpha = \angle CNA = \angle CNS - \angle ANS\]

\[\beta = \angle CNB = \angle CNS + \angle ANS\]