모바일 애드 혹은 네트워크에서의 동적 다중전송속도 경로 배정 알고리즘

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Outline

- Background
- Multi-rate Aware Sub-layer (MAS)
- Link status management
- Discussion
- Analysis on Tx time
- D-MAS
- Performance evaluation
- Conclusion
Mobile ad hoc networks
- Autonomous
  - Infrastructure-less network
  - STA: Terminal + Router
- Mobile
  - Wireless environment
  - Network topology varies over time
- Multi-hop communication

Multi-rate data transmission
- IEEE 802.11 standard
  - Provides various data rates at PHY
    - E.g., 1, 2, 5.5, 11 Mbps in IEEE 802.11b
- Multi-rate can be exploited to enhance the performance
rDCF

[Hao Zhu, et al., Infocom 2005]
- Utilizes multi-rate capability in WLAN environment
- Up to 2-hop relay only

\[
\frac{1}{\text{DataRate}(\text{src} \to \text{relay})} + \frac{1}{\text{DataRate}(\text{relay} \to \text{dst})} < \frac{1}{\text{DataRate}(\text{src} \to \text{dst})},
\]

s.t. relay \(\in\) neighbor _set(src)
MAS (Multi-rate Aware Sub-layer)

- Seeks for the path with **shortest Tx time**

- Changes the next-hop node

\[
\frac{1}{\text{DataRate} (\text{src} \rightarrow \text{relay})} + \frac{1}{\text{DataRate} (\text{relay} \rightarrow \text{dst})} < \frac{1}{\text{DataRate} (\text{src} \rightarrow \text{dst})},
\]

s.t. \( relay \in \text{neighbor} \_ \text{set} (\text{src}) \)
MAS protocol

- Located between MAC and Network layers

MAS protocol stack

<table>
<thead>
<tr>
<th>Transport Layer (TCP, UDP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network Layer (AODV, DSR)</td>
</tr>
<tr>
<td><strong>Multi-rate Aware Sub Layer</strong></td>
</tr>
<tr>
<td>MAC Layer (IEEE 802.11b)</td>
</tr>
<tr>
<td>Physical Layer</td>
</tr>
</tbody>
</table>

MAS header format

<table>
<thead>
<tr>
<th>MAC Header</th>
<th>MAS Header</th>
<th>IP Header</th>
<th>Payload</th>
</tr>
</thead>
<tbody>
<tr>
<td>TTL</td>
<td></td>
<td>Next-hop IP Address</td>
<td></td>
</tr>
<tr>
<td>0 1</td>
<td>7 8</td>
<td>39</td>
<td></td>
</tr>
</tbody>
</table>

0: MAS Valid Bit
Link status management

**Neighbor table**
- Maintains link status of up to 2-hop neighbors
  - Link status: \{src, dst, data rate, lifetime\}
    - The link turns invalid after the lifetime

1) **Neighbor discovery msg**
   - Periodically broadcasted to 1-hop neighbors

2) **Neighbor reply msg**
   - In response to the neighbor discovery msg
   - Contains the data rate of the link
     - Assuming the link is symmetric
   - Gives each link entry a lifetime
     - e.g., 2 times the neighbor notify period

3) **Neighbor notify msg**
   - Periodically broadcasted
     - Contains its 1-hop link table
   - Each STA can know its 2-hop link status
Overheads

- Backoff overhead
  - Idle slots due to backoff process
- Collision overhead
  - Wasted slots due to collision

Thus,

- In some cases, the metric below may not work
  - 2-hop relay may not take shorter time

\[
\frac{1}{\text{DataRate}(\text{src} \to \text{relay})} + \frac{1}{\text{DataRate}(\text{relay} \to \text{dst})} < \frac{1}{\text{DataRate}(\text{src} \to \text{dst})},
\]

s.t. \( \text{relay} \in \text{neighbor}_{\text{set}}(\text{src}) \)

- Should take the overheads into consideration
- Beneficial particularly in,
  - TCP ACK segment
  - Control frames
    - E.g., AODV RREQ, RREP packets
Analysis on transmission time

- **1-hop Tx time, \( T \)**
  \[
  T = T_s + N_{cum} T_c + O_{bo}
  \]

- **Time for successful Tx, \( T_s \)**
  \[
  T_s = \frac{H_{phy} + ACK}{BasicRate} + SIFS + DIFS + \frac{H_{mac} + E[P]}{DataRate} + 2\delta
  \]

- **Time for collision, \( T_c \)**
  \[
  T_c = \frac{H_{phy}}{BasicRate} + SIFS + DIFS + \frac{H_{mac} + E[P^*]}{DataRate} + \delta
  \]

- **Collision probability, \( P_c \)**
  \[
  P_c = 1 - (1 - \tau)^{n-1}, \quad \tau = \frac{1}{n\sqrt{T_c / 2\sigma}}
  \]

- **Number of collisions, \( N_{cum} \)**
  \[
  N_{cum} = \sum_{i=1}^{i=m} (i)(P_c)^i (1 - P_c), \quad m = \log_2\left(\frac{CW_{max}}{CW_{min}}\right)
  \]

- **Backoff overhead, \( O_{bo} \)**
  \[
  O_{bo} = \sum_{i=0}^{i=m} (P_c)^i (1 - P_c) \times 2^i \frac{CW_{min}}{2\sigma}
  \]

Ref: G. Bianchi [IEEE JSAC, 2000]

- **\( T \): 1-hop Tx time**
- **\( T_s \): time for successful Tx**
- **\( T_c \): time for collision**
- **\( N_{cum} \): number of collisions**
- **\( O_{bo} \): backoff overhead**
- **\( P_c \): collision probability**
- **\( n \): number of STA**
- **\( \sigma \): slot time**
- **\( \delta \): propagation delay**
- **\( E[P] \): avg packet size**
- **\( H_{phy} \): PHY header size**
- **\( H_{mac} \): MAC header size**
• Dynamically determines whether to relay or not
• New metric
  ▪ Assuming **saturated** network
  ▪ Considers both **data rate** and **overheads**
    • Can be calculated in the constant time
      \[ T_{\text{src} \rightarrow \text{dest}} > T_{\text{src} \rightarrow \text{relay}} + T_{\text{relay} \rightarrow \text{dest}} \]

• **Relay-preferable frame size**
Performance evaluation (1/2)

- Simulation environment
  - NS-2
  - IEEE 802.11b, AODV
  - TCP traffic
  - Parameters
    - \{DIFS, SIFS, σ, δ\} : \{50, 20, 10, 1\} μs
    - \{CW_{\text{min}}, CW_{\text{max}}\} : \{32, 1024\}

- Simulation topology
Performance evaluation (2/2)

- TCP goodput w.r.t. packet size
  - Basic: basic route
Conclusion

❖ **Summary**
  - Exploit **Multi-rate** in MANET environment
  - Consider backoff and collision **overheads**
  - **Independent** of the existing Routing, MAC protocols

❖ **Future work**
  - Estimation of the network status
  - More than 2-hop relay
  - Extensive simulations
Thank you

Q&A