Routing in Multi-Radio, Multi-Hop Wireless Mesh Networks

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Outline

- Introduction
- The MR-LQSR Protocol
- Simulation Result
- Conclusion
Introduction

- There is no standard routing protocol which be made in ad hoc networks
- Source routing mechanism
- The MR-LQSR is a routing protocol with the metric
- The goal of the *metric* is to choose a high-throughput path between a source and a destination
Introduction

- Our metric assigns weights to individual links based on Expected Transmission Time (ETT)
- The ETT is a function of the loss rate and the bandwidth of the link
Introduction

- **Define of ETX**
  - Expect Transmission Count [15]
    \[ p = 1 - (1 - p_f) \times (1 - p_r) \]
  - \( p \) denote the probability that the packet transmission from X to Y is not successful
    \[ s(k) = p^{k-1} \times (1 - p) \]
  - \( s(k) \) denote the probability that the packet will be successfully delivered after \( k \) attempts

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Wu Chih-Jen, MNET Lab
Introduction

Define of ETX

\[ ETX = \sum_{k=1}^{\infty} k \times s(k) = \frac{1}{1 - p} \]

The expected number of transmission required to successfully deliver a packet from X to Y is denoted by ETX.

\[ ETT = ETX \times \frac{S}{B} \]

- S: size of the packet
- B: bandwidth
The MR-LQSR Protocol

- MR-LQSR (Multi-Ratio Link-Quality Source Routing)
  - assigns a weight to the links a node has with its neighbor
  - Uses the link weights to find a good path for a given destination
- We assume that if a node has multiple radios, they are turned to different, non-interfering channels.
The MR-LQSR Protocol

- Our path metric is called Weighted Cumulative ETT (WCETT)

\[ WCETT = \sum_{i=1}^{n} ETT_i \]

- For a path consisting of \( n \) hops

\[ X_j = \sum_{\text{Hop } i \text{ is on channel } j} ETT_i \quad 1 \leq j \leq k \]

- \( X_j \) is the sum of transmission times of hops on channel \( j \)
The MR-LQSR Protocol

\[ WCET = (1 - \beta) \sum_{i=1}^{n} ETT_i + \beta \max_{1 \leq j \leq k} X_j \]

- The first term is the sum of transmission times along all hops in the network. This reflects the total resource consumption along this path.

- The second term reflects the set of hops that will have the most impact on the throughput of this path.
The MR-LQSR Protocol

<table>
<thead>
<tr>
<th>Path</th>
<th>Sum</th>
<th>Max</th>
<th>WCETT ($\beta = 0.9$)</th>
<th>WCETT ($\beta = 0.1$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>27</td>
<td>22</td>
<td>22.5</td>
<td>26.5</td>
</tr>
<tr>
<td>2</td>
<td>33</td>
<td>22</td>
<td>23.1</td>
<td>31.9</td>
</tr>
<tr>
<td>3</td>
<td>34</td>
<td>20</td>
<td>21.4</td>
<td>32.6</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>
The MR-LQSR Protocol

<table>
<thead>
<tr>
<th></th>
<th>$\beta = 0$</th>
<th>$\beta = 0.1$</th>
<th>$\beta = 0.5$</th>
<th>$\beta = 0.9$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Throughput (Kbps)</td>
<td>2726</td>
<td>2939</td>
<td>2989</td>
<td>2897</td>
</tr>
<tr>
<td>Path Length (Hops)</td>
<td>3.1</td>
<td>3.9</td>
<td>3.0</td>
<td>4.0</td>
</tr>
<tr>
<td>CDI</td>
<td>0.23</td>
<td>0.25</td>
<td>0.47</td>
<td>0.47</td>
</tr>
</tbody>
</table>

$\beta$ can be seen as offering a tradeoff between maximizing the throughput of a single flow and the consuming fewer global resource.
Simulation Result
Simulation Result

ETX (Single Radio)

WCETT (Single Radio)
Simulation Result

ETX (Two radios)

WCETT (Two radios)
Simulation Result

![Graphs showing simulation results for median throughput and diversity index across different path lengths with varying β values.](image-url)
Simulation Result

![Graph showing simulation results](image)

- WCETT ($\beta=0$)
- WCETT ($\beta=0.1$)
- WCETT ($\beta=0.5$)
- WCETT ($\beta=0.9$)
- ETX
Conclusion

- A routing protocol MR-LQSR with a new metric WCETT is implemented.
- WCETT allows us to tradeoff channel diversity and path length by changing the value of the control parameter $\beta$. 