ANSAR: Ad hoc Network State Aware Routing Protocol

Jie Xiang

jxiang@simula.no

Simula Research Laboratory
Outline

- Issues in Ad hoc Networks
- Related Works
- Description of ANSAR
- Simulation
- Conclusion
Issues in Ad hoc networks

- Limited power available at the nodes.
- The topology of Ad hoc Networks can change arbitrarily.
- The energy constrained network will experience Ideal state, Congested State, and Energy Critical State
# Related Works

<table>
<thead>
<tr>
<th>metrics</th>
<th>example</th>
<th>drawbacks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shortest hop metric</td>
<td>DSR, AODV, DSDV</td>
<td>Easily concentrate traffic on centrally located nodes</td>
</tr>
<tr>
<td>Load Aware Metric</td>
<td>DLAR</td>
<td>May divert load to low energy capacity nodes</td>
</tr>
<tr>
<td>Energy Aware Metric</td>
<td>MTPR, MBCR, MMBCR</td>
<td>Tend to concentrate traffic load on nodes with high battery capacity.</td>
</tr>
</tbody>
</table>
Problem Statement

• Problem
  – Limitation of nodes’ battery capacity
  – Network state changed from ideal to critical
  – Dynamic topologies

• Objective
  – Adaptive to the network state
  – Optimize the network life time, minimize the energy consumed.
Assumptions

• Energy consumed due to computation related activities is negligible compared to communication related activities.

• All data packets are of the same size.

• The energy consumed per unit transmission, reception and overhearing of a packet are constant, denoted by $e_{ix}$, $e_{ir}$, $e_{io}$ respectively for node $i$. 
Notations

• RBC: Remaining Battery Capacity
• ED: Energy Drained
• EDR: Energy Drain Rate
• NL: Node Lifetime
• PL: Path Lifetime
ANSAR routing metric deduction

\[
ED_i(t) = \int_{t}^{t-T} P_i(t) dt = \int_{T_i_x(t)} P_{i_x} dt + \int_{T_i_r(t)} P_{i_r} dt + \int_{T_i_o(t)} P_{i_o} dt = RBC_i(t-T) - RBC_i(t)
\]

The Energy Drained of node \(i\) at time \(t\)

\[
EL_i(t) = n_{i_x}(t) \times e_{i_x} + n_{i_r}(t) \times e_{i_r} + n_{i_o}(t) \times e_{i_o}
\]

The Energy consumed: calculated by the node’s Load

\[
EL_i(t) = ED_i(t)
\]
ANSAR routing metric deduction

\[ EDR_i(t) = \frac{ED_i(t)}{T} = \frac{EL_i(t)}{T} \]

\[ = \frac{n_{ix}(t) \times e_{ix} + n_{ir}(t) \times e_{ir} + n_{io}(t) \times e_{io}}{T} \]

Energy Drain Rate

\[ NL_i(t) = \frac{RBC_i(t)}{EDR_i(t)} \]

\[ = \frac{RBC_i(t) \times T}{n_{ix}(t) \times e_{ix} + n_{ir}(t) \times e_{ir} + n_{io}(t) \times e_{io}} \]
**ANSAR routing metric deduction**

\[
NL_i(t) = \frac{T}{K_i} \cdot \frac{RBC_i(t)}{L_i(t)} = K \frac{RBC_i(t)}{L_i(t)}
\]

- **Node Life**
- **Path Life**
- **The best path**
- **The reserved path**
ANSAR routing metric

\[ M = \begin{cases} \frac{\partial P}{\max \{PL_p \mid \forall p \in A\}} & \text{for } E > \gamma \\ \text{for } E \leq \gamma & \text{for } E \leq \gamma \end{cases} \]

Using shortest path in ideal state
Using jointed load-energy optimized path in congested and energy critical state.
ANSAR generation model
ANSAR descriptions

• Route discovery
  – Finds rout on-demand using RREQ, RREP messages.

• Route maintenance
  – Handle route error by RERR messages.
  – Verify secondary path by RSP, RSA messages.
Process of Source Nodes

• Send RREQ message to its neighbor nodes to initialize a route discovery

• Remove path in routing tables while receiving RERR messages, and verify the secondary path.
Process of Intermediate Nodes

Receive RREQ Packet

\[ RBC < \lambda \]

- If Yes (Y), then \[ ETF = 1 \]
- If No (N), then \[ NL < PL \]

- If Yes (Y), then \[ PL = NL \]
- If No (N), then Forward RREQ Packet
Process of Destination Nodes

Receive RREQ Packet

Route Wait Timer

PATH 1 | ETF | PL1

PATH i | ETF | PLi

PATH n | ETF | PLn

M

Pb

Pr

Send RREP Packet
# Simulation: NS-2

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
<th>Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of nodes</td>
<td>50</td>
<td>Energy drain per data transmission $P_{tx}$</td>
<td>0.4J</td>
</tr>
<tr>
<td>Number of connections</td>
<td>15</td>
<td>Energy drain per data reception $P_{rx}$</td>
<td>0.2J</td>
</tr>
<tr>
<td>Channel data rate</td>
<td>1Mbps</td>
<td>Scope of environment</td>
<td>1500m x 300m</td>
</tr>
<tr>
<td>Transmission range</td>
<td>250m</td>
<td>Mobility of nodes</td>
<td>[0, 20m/s]</td>
</tr>
<tr>
<td>Node's Initial Energy</td>
<td>80J</td>
<td>Traffic</td>
<td>CBR (512 bytes/packet)</td>
</tr>
<tr>
<td>Interface Queue Size</td>
<td>50</td>
<td>Energy threshold</td>
<td>16J</td>
</tr>
<tr>
<td>Route Select wait time</td>
<td>0.02sec</td>
<td>Observation Time</td>
<td>900 seconds</td>
</tr>
</tbody>
</table>
Performance Evaluation: Average end-to-end delay

![Graph showing average end-to-end delay for different send rates and protocols]

- **DSR**
- **ANSAR**
- **MBCR**
- **MMBCR**
- **DLAR**

[ANSAR]
Performance Evaluation: Throughput

![Graph showing throughput performance of different protocols](chart.png)

- **DSR**
- **ANSAR**
- **MBCR**
- **MMBCR**
- **DLAR**

[ simularesearchlaboratory ]
Performance Evaluation: Control packet overhead

[Graph showing comparison of send rates and overhead for different protocols: DSR, ANSAR, MBCR, MMBCR, DLAR. The graph plots send rate (packets/second) against overhead.]
Performance Evaluation: Normalized Average Energy Consumption

- DSR
- ANSAR
- MBCR
- MMBCR
- DLAR
Conclusions and Future work

• ANSAR utilize combined state metrics to adapt to the current state of the network.

• The simulation results show that ANSAR has some advantage to the related routing protocols,

• Some parameters in ANSAR still needs to be optimized, such as energy threshold.
Thank you