6LoWPAN
Simple Fragment Recovery

(draft-thubert-6lo-forwarding-fragments-00)

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What’s new

- Fragment forwarding
  - Using the datagram tag as a switchable label
  - Acks are used to clean intermediate states
  - ECN echo restored

- Removed Compressed ack bitmap

- Needed for 6TiSCH when operating on 15.4 2006 PHY

- Quite stable draft
Need for fragment recovery

• Considering
  – that 6LoWPAN packets can be as large as 1280 bytes
  – that Source routing requires space for routing headers
  – that a 802.15.4 frame with security will carry in the order of 80 bytes of effective payload,

=> An IPv6 packet might be fragmented into > 16 fragments at the 6LoWPAN shim layer.

• This level of fragmentation is much higher than that traditionally experienced over the Internet with IPv4 fragments, already known as harmful.

• At the same time, the use of radios increases the probability of transmission loss but retry only 1 hop

• Mesh-Under and fragment routing techniques compound that risk over multiple hops with no ack
Other problems related to frags

• Hop by Hop recomposition
  – Should be avoided: latency and memory hit

• Multipath
  – Forwarding fragments over multipath multiplies the impact of an anomaly

• Recovery buffers Lifetime
  – Terminating device with limited capacity may have trouble maintaining buffers. How long?
  – Intermediate routers congestion
Fragment Recovery proposal

• 32 bits SAck Bitmap
• Variable window size for congestion control
• Round Robin for multipath
• 4 new dispatch types

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Header Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>11 101000</td>
<td>RFRAG</td>
<td>Recoverable Fragment</td>
</tr>
<tr>
<td>11 101001</td>
<td>RFRAG-AR</td>
<td>RFRAG with Ack Request</td>
</tr>
<tr>
<td>11 101010</td>
<td>RFRAG-ACK</td>
<td>RFRAG Acknowledgment</td>
</tr>
<tr>
<td>11 101011</td>
<td>RFRAG-AEC</td>
<td>RFRAG Ack with ECN Echo</td>
</tr>
</tbody>
</table>
Fragment Forwarding proposal

- Frags & Acks have a datagram tag
- Unique for the source if the tag
- Proposal uses the datagram tag as a label
- First fragment sets up a bidir label path
- Final ack & errors clean it up
- Next fragments are label swapped along the same path
Recoverable Fragment Dispatch type and Header

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

X (check) bit
When set, the sender requires an Acknowledgement from the receiver

Sequence
The sequence number of the fragment.
Fragments are numbered \([0..N]\) where \(N\) is in \([0..31]\).
The ack now has ECN echo:

Y: 1 bit; Explicit Congestion Notification (ECN) signalling

--- Fragment with sequence 10 was received

--- Fragment with sequence 00 was received
ECN use

• Indicate Congestion in the LoWPAN
  – End to End effect on Transport
  – Potential use at ISA100.11a and 6TiSCH
  – Local Effect on Fragment flow control

• Early detection
  – Avoid Wasteful discard of packets
  – Conditions equivalent to RED
  – Setting ECN is out of scope (just echo)
Explicit Congestion Notification

• ECN in IPv6: Traffic Class bits 6-7

<table>
<thead>
<tr>
<th>Binary</th>
<th>Keyword</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>Not-ECT (Not ECN-Capable Transport)</td>
<td>[RFC 3168]</td>
</tr>
<tr>
<td>01</td>
<td>ECT(1) (ECN-Capable Transport(1))</td>
<td>[RFC 3168]</td>
</tr>
<tr>
<td>10</td>
<td>ECT(0) (ECN-Capable Transport(0))</td>
<td>[RFC 3168]</td>
</tr>
<tr>
<td>11</td>
<td>CE (Congestion Experienced)</td>
<td>[RFC 3168]</td>
</tr>
</tbody>
</table>

– Not compressed separately by 4944
– Isolated in RFC 6282 section 3.1.1. Base Format

• ECN Echo
– Not an IP function (usually transport)
– Thus provided by this draft between fragmentation endpoints
Questions