# IPv6 over Low power WPAN WG (6lowpan)

Chairs:

**Geoff Mulligan <geoff@mulligan.com>**

**Carsten Bormann <cabo@tzi.org>**

Mailing List:

**6lowpan@ietf.org**

Jabber:

**6lowpan@jabber.ietf.org**

- **We assume people have read the drafts**
- **Meetings serve to advance difficult issues by making good use of face-to-face communications**
- **Be aware of the IPR principles, according to RFC 3979 and its updates**

✓Blue sheets
✓Scribe(s)

# Milestones (from WG charter page)

Document submissions to IESG:

- Aug 2008  x 2 Improved Header Compression (PS)
- Aug 2008  // 6 Security Analysis (Info)
- Sep 2008  // 3 Architecture (Info)
- Sep 2008  x 4 Routing Requirements (Info)
- Nov 2008  x 1 Bootstrapping and ND Optimizns (PS)
- Dec 2008  x 5 Use Cases (Info)

Also: running documents for implementers, interop

# 79th IETF: 6lowpan WG Agenda

| | | | |
|---|---|---|---|
| 15:20 | Introduction, Agenda | Chairs | (10) |
| 15:30 | 1 – finishing ND | | |
| 15:30 | ND-14 | ZS | (15) |
| 15:45 | NCE/next-hop | SS | (15) |
| 16:00 | multihop DAD, context life | EN | (30) |
| 16:30 | Discussion | | |
| 17:10 | 3 – status security work | | |
| 17:20 | 0 – new work on HC | | |
| 17:25 | TCP HC | DR | (15) |
| 17:40 | Generic HC | CB | (10) |
| 17:50 | 0 – miscellaneous | Chairs | (5) |
| 17:55 | Next steps/Rechartering...18:10 | Chairs | (15) |

# 79th IETF: 6lowpan WG Agenda

| | | | |
|---|---|---|---|
| 15:20 | Introduction, Agenda | Chairs | (10) |
| 15:30 | 1 – finishing ND | | |
| 15:30 | ND-14 | ZS | (15) |
| 15:45 | NCE/next-hop | SS | (15) |
| 16:00 | multihop DAD, context life | EN | (30) |
| 16:30 | Discussion | | |
| 17:10 | 3 – status security work | | |
| 17:20 | 0 – new work on HC | | |
| 17:25 | TCP HC | DR | (15) |
| 17:40 | Generic HC | CB | (10) |
| 17:50 | 0 – miscellaneous | Chairs | (5) |
| 17:55 | Next steps/Rechartering...18:10 | Chairs | (15) |

# “Neighbor Discovery Optimization for Low-power and Lossy Networks”

*draft-ietf-6lowpan-nd-14*

*Zach Shelby, Samita Chakrabarti, Erik Nordmark*

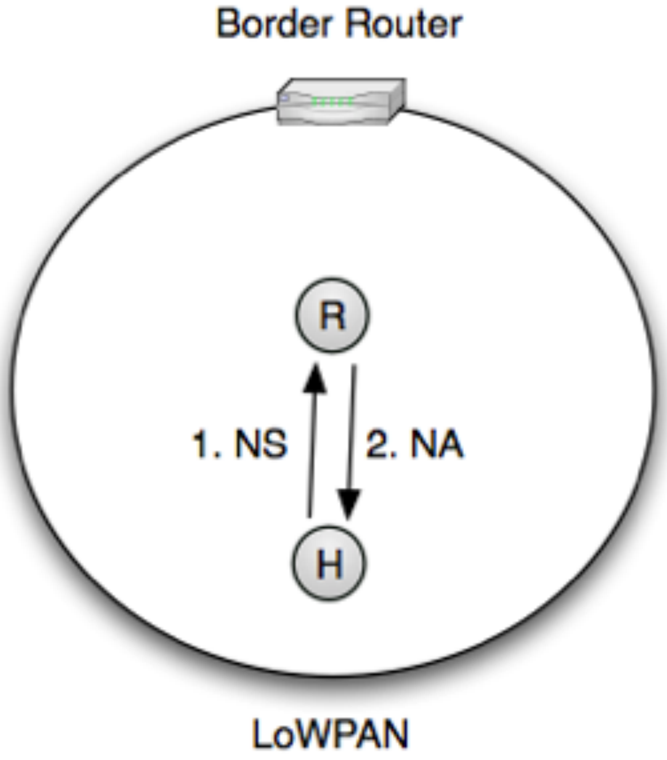
# Progress since Maastricht

- nd-12
  - Aligned ABRO fields for 32-bit reserved (#90)
  - Clarifications and example of router interaction (#91)
  - Temporary NCE added (#87)
- nd-13
  - Error-to solution added for duplicate MACs (#126)
- nd-14 (to resolve WGLC comments)
  - New DAR and DAC multihop DAD messages
  - MULTIHOP_HOPLIMIT = 64
  - Clarified host de-registration
  - Router next-hop determination section added
  - Removed 6CO infinite lifetime

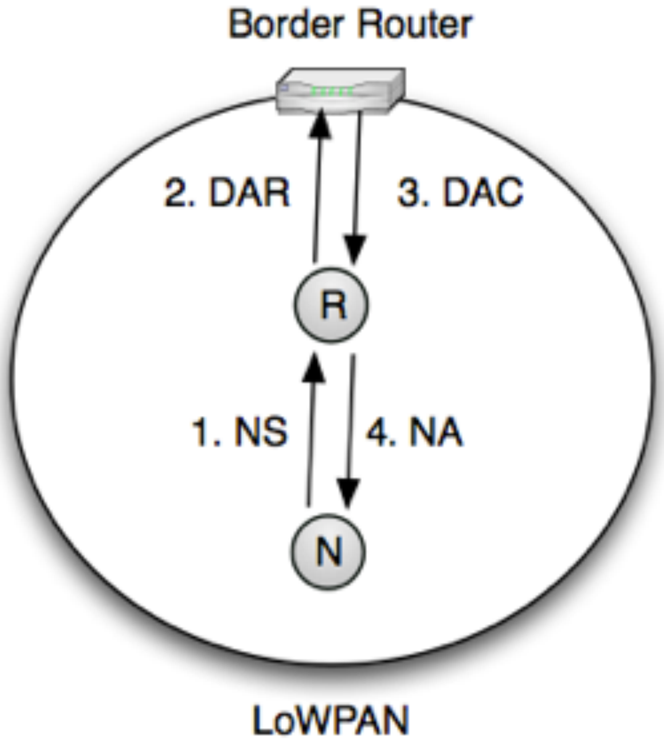
# Current status

- WGLC issues have been resolved
- TODOs found by the authors:
  - Clarification on context distribution lifecycle (#129)
    - Define MIN_CONTEXT_CHANGE_DELAY as greater than the default router lifetime
  - Editorial text trimming (less repetition)
  - General editing round needed
- Next step
  - Release nd-15 within 2 weeks

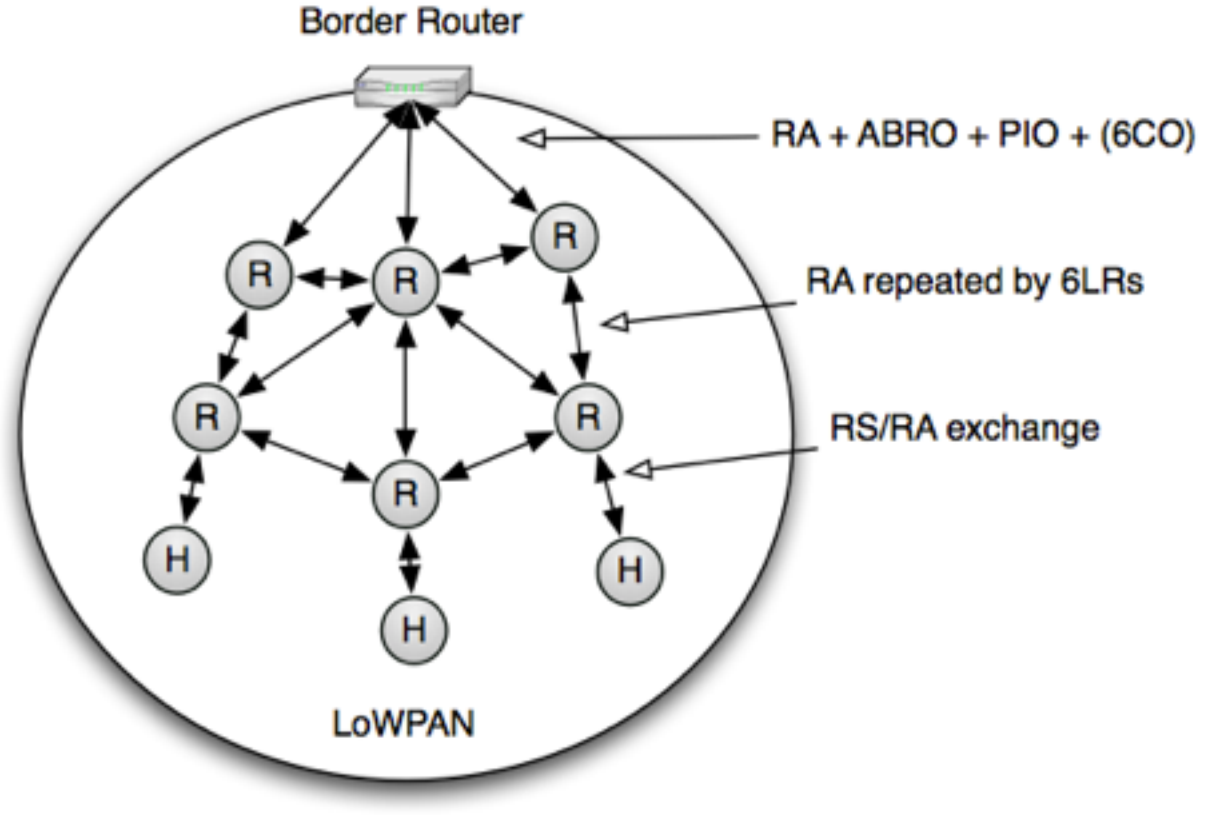
# Host-Router interface



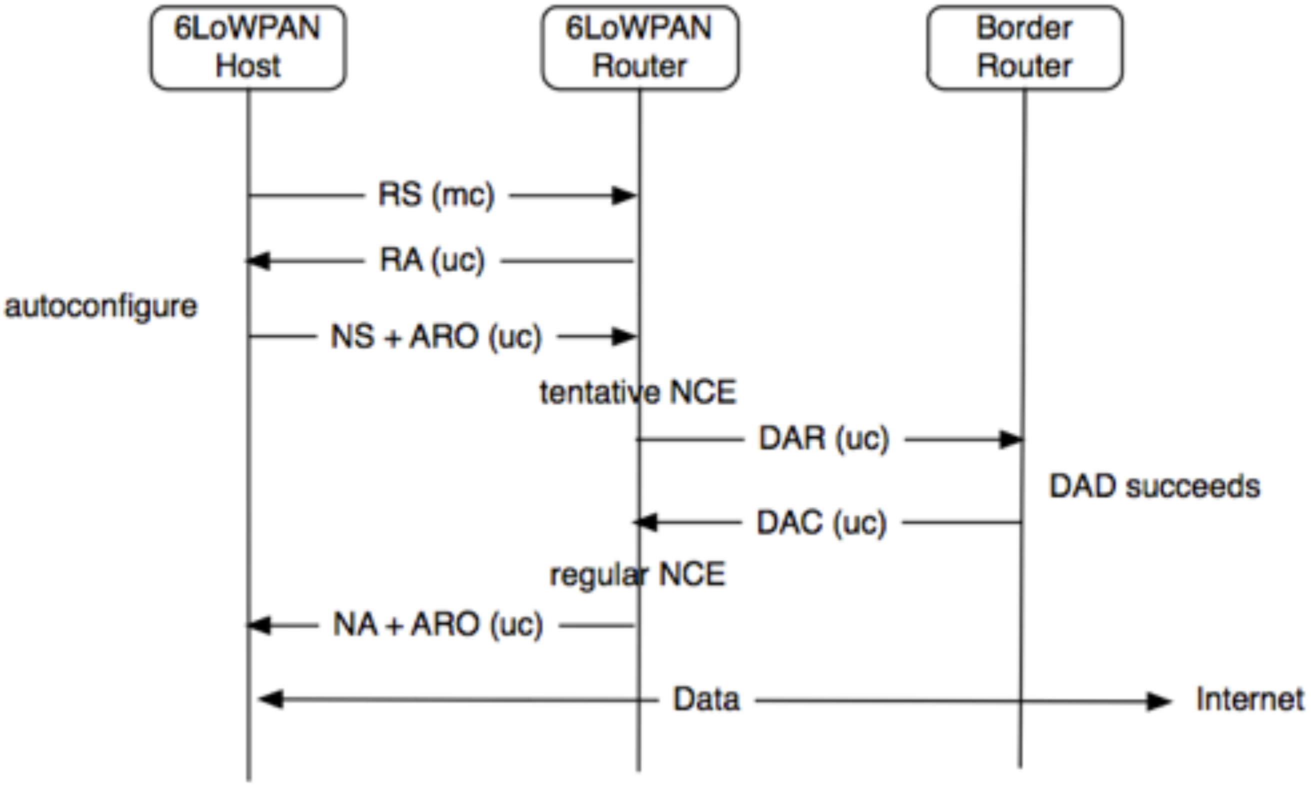
# Duplicate address detection



# Multihop prefix distribution



# Put it all together...



Legend:
(mc) = Multicast
(uc) = Unicast

# 79th IETF: 6lowpan WG Agenda

| | | | |
|---|---|---|---|
| 15:20 | Introduction, Agenda | Chairs | (10) |
| 15:30 | 1 – finishing ND | | |
| 15:30 | ND-14 | ZS | (15) |
| 15:45 | NCE/next-hop | SS | (15) |
| 16:00 | multihop DAD, context life | EN | (30) |
| 16:30 | Discussion | | |
| 17:10 | 3 – status security work | | |
| 17:20 | 0 – new work on HC | | |
| 17:25 | TCP HC | DR | (15) |
| 17:40 | Generic HC | CB | (10) |
| 17:50 | 0 – miscellaneous | Chairs | (5) |
| 17:55 | Next steps/Rechartering…18:10 | Chairs | (15) |

# “Neighbor Discovery Optimization for Low-power and Lossy Networks”

*draft-ietf-6lowpan-nd-14*

*Zach Shelby, Samita Chakrabarti, Erik Nordmark*

*zach@sensinode.com*

*samitac@ipinfusion.com*

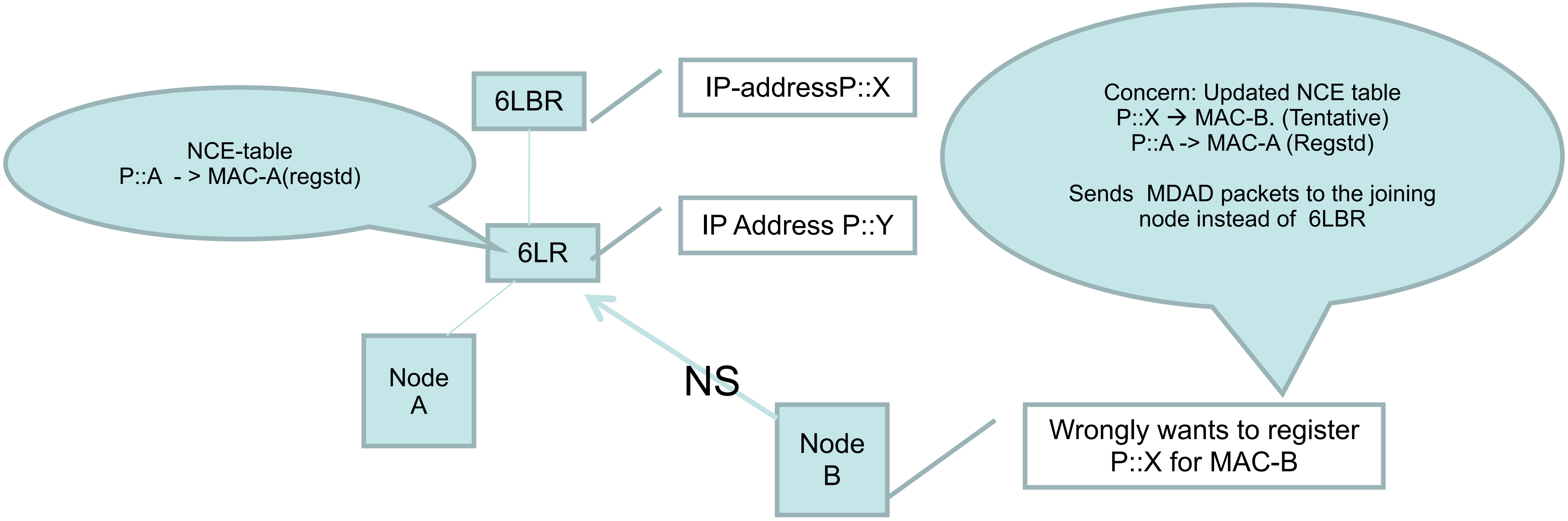
*nordmark@orcale.com*

# Clarification on NCE and NextHop Determination

## WG Comments [ Colin and Others]

- Concern on possible neighbor  table collision

Example Scenario


NCE-table
P::A  - > MAC-A(regstd)
6LBR
IP-addressP::X
6LR
IP Address P::Y
Node A
NS
Node B
Concern: Updated NCE table
P::X → MAC-B. (Tentative)
P::A -> MAC-A (Regstd)
Sends  MDAD packets to the joining node instead of  6LBR
Wrongly wants to register P::X for MAC-B

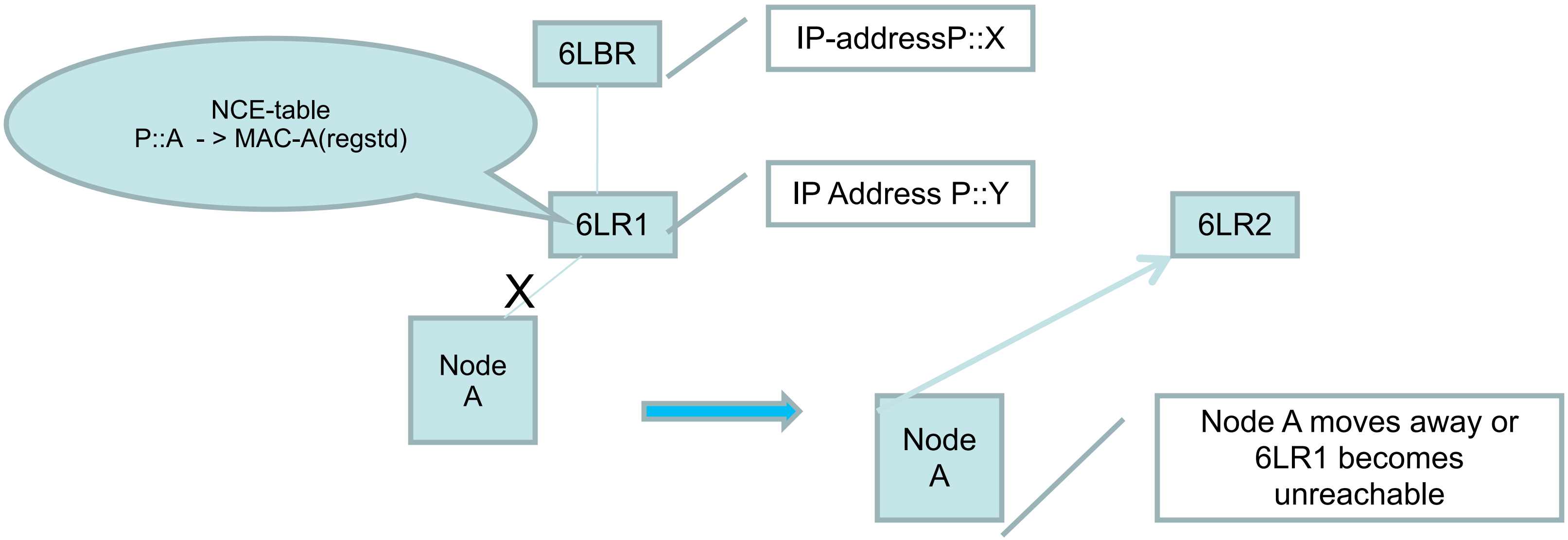
Conclusion:  Clarification  is required for proper understanding of NCE management

# Clarification on NCE and NextHop Determination

## WG Comments [ Colin and Others]

- Concerns on left-behind NCE when node moves away before the registration expiry

Example Scenario



Conclusion: Clarification is required for proper understanding of NCE management

# Action Taken in ND-14

- Clarification(1)
  - Tentative NCEs are created when Multihop DAD is performed by the 6LR [ already described in section 8.2]
    - We added some text in section 3.5 regarding that as well. However, in nd-15 we will do some more checks/cleanup to remove inconsistency and redundancy
  - Sec 6.5.4: Next Hop Determination at 6LR
    - Tentative or garbage-collectable NCEs are not used for on-link status determination
      - As per RFC 4861 and general IP networking principle, Routers should check the routing table for sending the MDAD packets to 6LBR

# Action Taken in ND-14

- Clarification(2) for concern on left-behind NCE on 6LRs
  - Sec 1.3: If possible a moving node should de-register itself from the current default router and then register itself with a new default-router
  - If it is a run-away node, NCE entry expires after registration-lifetime. 6LR will transmit data for that NCE until it expires
    - Use low registration lifetime for nodes where the network is unstable or nodes are mobile

# ND-14 : Clarification(2)…

- Mobility optimization is out of scope of the 6LoWPAN ND document.
- More optimization may be possible with movement detection and signaling the previous default-router to delete the NCE before registration expiry , but more thoughts and investigation are needed. such solution may be formed as an additional extension on local mobility optimization.
- Section 6.5.3 mentions that Routing protocol be notified with addition or removal of NCEs ; Thus a Routing protocol may also be used to notify the previous 6LR that the particular node has moved away

# Clarification/Guideline for Implementation

- Problem # 127 Clarification on optional/Mandatory languages
  - Optional behaviors are regarded as SHOULD for implementation and MAY for deployment
  - Changes were made in section 1.3 and section 1.4 is added to reflect the above assertion
  - Section 13 (Guidelines for New Features) was added to clarify implementation and deployment recommendations for 6LN, 6LBR and 6LR nodes.

# 79th IETF: 6lowpan WG Agenda

| | | | | |
|---|---|---|---|---|
| 15:20 | | Introduction, Agenda | Chairs | (10) |
| 15:30 | | 1 – finishing ND | | |
| | 15:30 | ND-14 | ZS | (15) |
| | 15:45 | NCE/next-hop | SS | (15) |
| | 16:00 | multihop DAD, context life | EN | (30) |
| | 16:30 | Discussion | | |
| 17:10 | | 3 – status security work | | |
| 17:20 | | 0 – new work on HC | | |
| | 17:25 | TCP HC | DR | (15) |
| | 17:40 | Generic HC | CB | (10) |
| 17:50 | | 0 – miscellaneous | Chairs | (5) |
| 17:55 | | Next steps/Rechartering...18:10 | Chairs | (15) |

# Neighbor Discovery Duplicate Address Request and Confirmation

<draft-ietf-6lowpan-nd-14.txt>

Erik Nordmark
erik.nordmark@oracle.com

# Multihop DAD Issue in -13

- Two different forms of ARO
  - Length=2 for host to router communication
  - Length=4 for multihop DAD
- The NS/NA with ARO Length=4 was quite different than anything else
  - Hoplimit=255 check does not apply
  - MUST NOT modify the NCEs
- Made it difficult to implement hoplimit check
- Hard for firewall to filter out multihop DAD messages

# Make it more clear; separate ICMP types for multihop DAD

- ARO now only has Length=2
- Duplicate Address Request (DAR) replaces multihop NS with ARO Length=4
- Duplicate Address Confirmation (DAC) replaces multihop NA with ARO Length=4
- DAR and DAC are not subject to hoplimit=255
- NS and NA are always subject to hoplimit=255
- The logic of multihop DAD is unchanged

# DAR/DAC message format

```
0                   1                   2                   3
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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |     Code      |           Checksum            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    Status     |   Reserved    |     Registration Lifetime     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
+                            EUI-64                             +
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
+                                                               +
|                                                               |
+                      Registered Address                       +
|                                                               |
+                                                               +
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

- 24 bytes shorter than NS with ARO

# Context distribution; unclear in -14

- Section 7.2 says
  - Only when it is reasonable to assume that this information was successfully disseminated SHOULD an option with C=1be sent, enabling the actual use of the context information for compression.
  - That is, in preparation for a change of context information, its dissemination SHOULD continue for at least MIN_CONTEXT_CHANGE_DELAY with C=0.  Only when it is reasonable to assume that the fact that the context is now invalid was successfully disseminated ...

# Context distribution;
# What is “reasonable”?

- Maximum default router lifetime 18 hours
  - Implies host will RS after at most 18 hours
  - RS triggers an RA with the newest 6CO
- Administrator can configure 6LRs to use shorter default router lifetime
- Suggestion: Replace MIN_CONTEXT_CHANGE_DELAY with “at least the configured default router lifetime”, and clarify that this is what “reasonable” means

# 79th IETF: 6lowpan WG Agenda

| | | | |
|---|---|---|---|
| 15:20 | Introduction, Agenda | Chairs | (10) |
| 15:30 | 1 – finishing ND | | |
| 15:30 | ND-14 | ZS | (15) |
| 15:45 | NCE/next-hop | SS | (15) |
| 16:00 | multihop DAD, context life | EN | (30) |
| 16:30 | Discussion | | |
| 17:10 | 3 – status security work | | |
| 17:20 | 0 – new work on HC | | |
| 17:25 | TCP HC | DR | (15) |
| 17:40 | Generic HC | CB | (10) |
| 17:50 | 0 – miscellaneous | Chairs | (5) |
| 17:55 | Next steps/Rechartering...18:10 | Chairs | (15) |

# 6CO Option

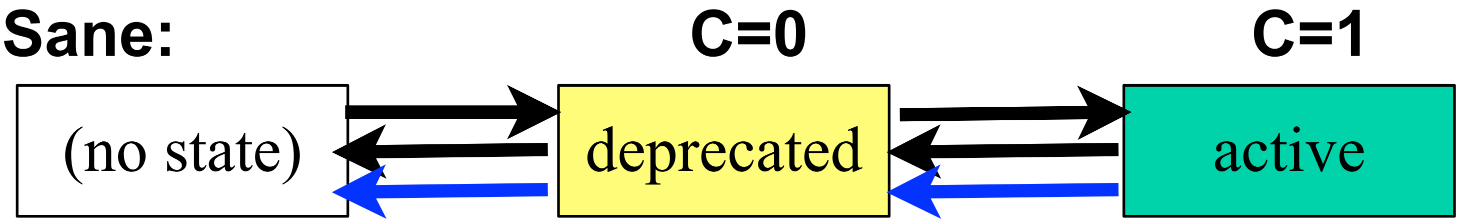
```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |    Length     |Context Length |_____|C|  CID  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|_______________________________|        Valid Lifetime         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
.                                                               .
.                        Context Prefix                         .
.                                                               .
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

               Figure 1: 6LoWPAN Context Option format
```

(valid lifetime up to 655350 s ≈ 7.6 days)

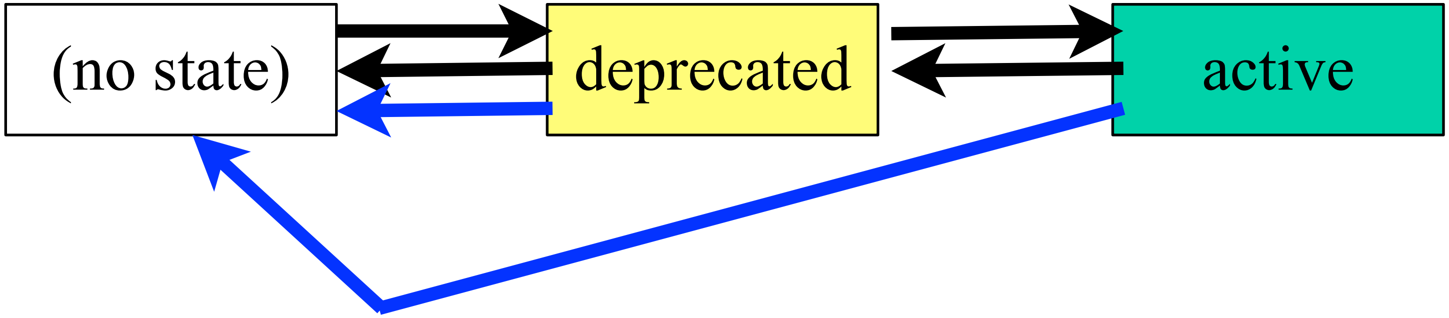
# 6CO state machine

- **Sane:**



  - **<u>active distribution</u> of updates goes right and left slowly**
  - **timeouts go left, through a deprecated state for a while**

- **Actual:**



# 79th IETF: 6lowpan WG Agenda

| | | | |
|---|---|---|---|
| 15:20 | Introduction, Agenda | Chairs | (10) |
| 15:30 | 1 – finishing ND | | |
| 15:30 | ND-14 | ZS | (15) |
| 15:45 | NCE/next-hop | SS | (15) |
| 16:00 | multihop DAD, context life | EN | (30) |
| 16:30 | Discussion | | |
| 17:10 | 3 – status security work | | |
| 17:20 | 0 – new work on HC | | |
| 17:25 | TCP HC | DR | (15) |
| 17:40 | Generic HC | CB | (10) |
| 17:50 | 0 – miscellaneous | Chairs | (5) |
| 17:55 | Next steps/Rechartering...18:10 | Chairs | (15) |

# 79th IETF: 6lowpan WG Agenda

| | | | |
|---|---|---|---|
| 15:20 | Introduction, Agenda | Chairs | (10) |
| 15:30 | 1 – finishing ND | | |
| 15:30 | ND-14 | ZS | (15) |
| 15:45 | NCE/next-hop | SS | (15) |
| 16:00 | multihop DAD, context life | EN | (30) |
| 16:30 | Discussion | | |
| 17:10 | 3 – status security work | | |
| 17:20 | 0 – new work on HC | | |
| 17:25 | TCP HC | DR | (15) |
| 17:40 | Generic HC | CB | (10) |
| 17:50 | 0 – miscellaneous | Chairs | (5) |
| 17:55 | Next steps/Rechartering...18:10 | Chairs | (15) |

# 79th IETF: 6lowpan WG Agenda

| | | | |
|---|---|---|---|
| 15:20 | Introduction, Agenda | Chairs | (10) |
| 15:30 | 1 – finishing ND | | |
| 15:30 | ND-14 | ZS | (15) |
| 15:45 | NCE/next-hop | SS | (15) |
| 16:00 | multihop DAD, context life | EN | (30) |
| 16:30 | Discussion | | |
| 17:10 | 3 – status security work | | |
| 17:20 | 0 – new work on HC | | |
| 17:25 | TCP HC | DR | (15) |
| 17:40 | Generic HC | CB | (10) |
| 17:50 | 0 – miscellaneous | Chairs | (5) |
| 17:55 | Next steps/Rechartering...18:10 | Chairs | (15) |

# TCP Header Compression for 6LoWPAN (draft-aayadi-6lowpan-tcphc-01)

Ahmed Ayadi, David Ros and Laurent Toutain

IETF-79 Beijing

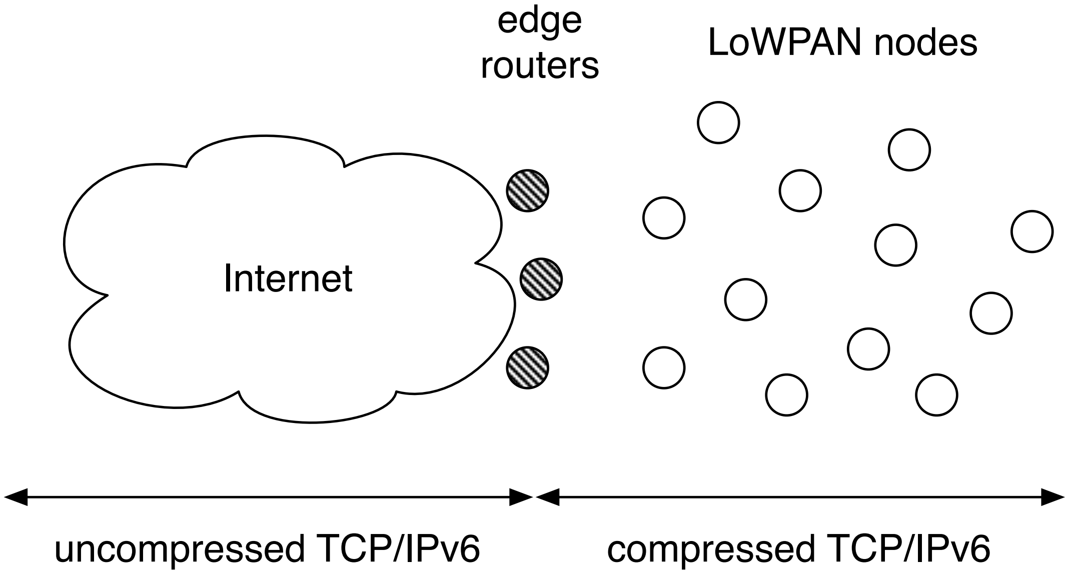
November 9, 2010

# Motivation

- TCP allows running useful services like remote login and HTTP in Low-power and Lossy Networks
- But: TCP header overhead is between 20 and 60 bytes
- Currently, LOWPAN_IPHC defines only a compression scheme for UDP (LOWPAN_NHC)
- Goal: define a TCP compression scheme compatible with 6LoWPAN, using LOWPAN_NHC
  - Outside to LoWPAN, LoWPAN to outside, LoWPAN to LoWPAN

# LOWPAN_TCPHC: overview

- TCPHC is implemented both on the Edge Router and on the (TCP end-point) LoWPAN node which save the context of the TCP connections

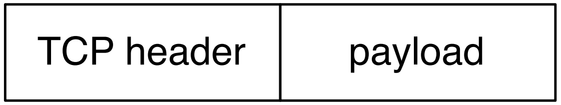


# LOWPAN_TCPHC: overview

- TCPHC:
  - does not compress TCP segments in the connection establishment phase (SYN)
    - replaces the source port and destination port by a Context IDentifier (CID)
  - sends only the bytes of dynamic fields (Sequence number, ACK number, Window) that have changed
  - removes unused bits (Reserved)
  - elides the TCP header-length field (value inferred at decompression)
  - compresses SACK and Timestamp TCP options

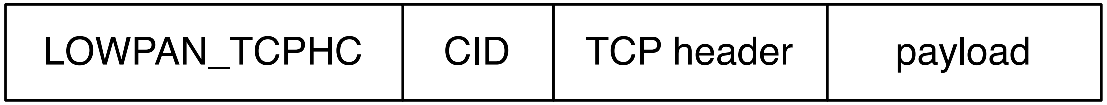
# LOWPAN_TCPHC header types

- Regular header (used outside the LLN)



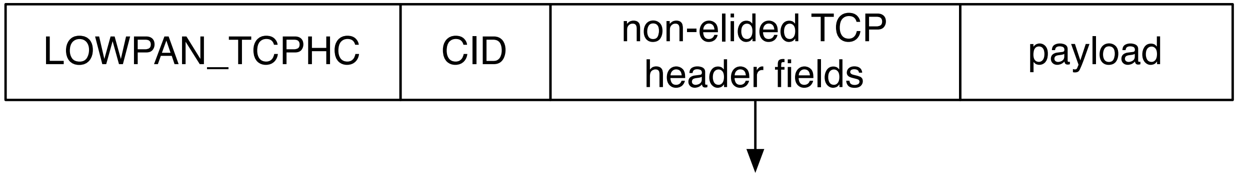
| TCP header | payload |
|---|---|

- Full header (sent at the connection establishment phase)



| LOWPAN_TCPHC | CID | TCP header | payload |
|---|---|---|---|

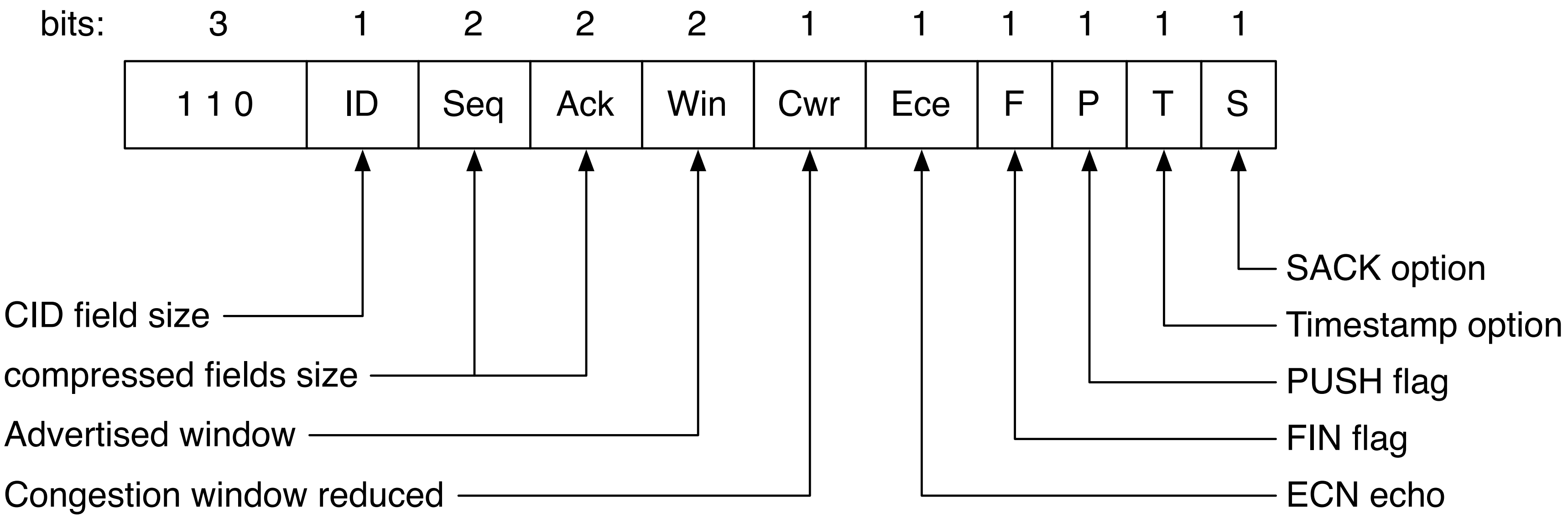
- Compressed header



| LOWPAN_TCPHC | CID | non-elided TCP header fields | payload |
|---|---|---|---|

compressed & uncompressed
fields, in TCP-header order

# LOWPAN_TCPHC format for compressed headers



| bits: | 3 | 1 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 1 0 | ID | Seq | Ack | Win | Cwr | Ece | F | P | T | S |

CID field size

compressed fields size

Advertised window

Congestion window reduced

SACK option

Timestamp option

PUSH flag

FIN flag

ECN echo

# Compression of TCP options

- MSS and SACK-permitted are sent uncompressed in SYN segments
- SACK:
  - Only one SACK block is allowed
  - SACK block values are replaced by their offset w.r.t. the ACK number
- Time Stamp:
  - Only bytes that have changed, compared to last segment, are carried in-line.
  - A bitmap field is added to describe if a byte is omitted or carried in-line.
- Other options are assumed to be unused / not useful in LNNs
  - E.g. Window Scale option (low bit rates, memory constraints)

# Current status

- We have an alpha version of TCPHC for Contiki OS already implemented
  - We plan to keep it in sync with the draft, and to release the code «soon»
  - Some (very) preliminary results
    - TCPHC reduces the TCP header to 6 bytes in more than 95% of cases
    - TCPHC reduces energy consumption by up to ~15%
- Interest in adopting LOWPAN_TCPHC as a WG item?

# 79th IETF: 6lowpan WG Agenda

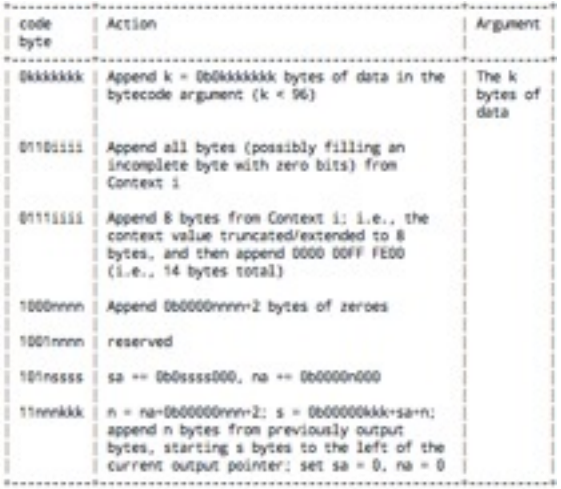
| | | | |
|---|---|---|---|
| 15:20 | Introduction, Agenda | Chairs | (10) |
| 15:30 | 1 – finishing ND | | |
| 15:30 | ND-14 | ZS | (15) |
| 15:45 | NCE/next-hop | SS | (15) |
| 16:00 | multihop DAD, context life | EN | (30) |
| 16:30 | Discussion | | |
| 17:10 | 3 – status security work | | |
| 17:20 | 0 – new work on HC | | |
| 17:25 | TCP HC | DR | (15) |
| 17:40 | Generic HC | CB | (10) |
| 17:50 | 0 – miscellaneous | Chairs | (5) |
| 17:55 | Next steps/Rechartering...18:10 | Chairs | (15) |

# New proposal: 6LoWPAN-GHC

- Generic compression of remaining headers
  and header-like payloads: ICMPv6, ND, RPL; DHCP; ...

- draft-bormann-6lowpan-ghc: simple LZ77 based on **bytecode**
  - **single-page** specification: simple
  - **stateless** (but can use 6LoWPAN-HC context)
- provides modest compression factors
  between 1.65 and 1.85 on realistic examples

- fits in 6LoWPAN-HC's NHC
- is this something we want to pursue?



| code byte | Action | Argument |
|---|---|---|
| 0kkkkkkk | Append k = 0b0kkkkkkk bytes of data in the bytecode argument (k < 96) | The k bytes of data |
| 0110iiii | Append all bytes (possibly filling an incomplete byte with zero bits) from Context i | |
| 0111iiii | Append 8 bytes from Context i; i.e., the context value truncated/extended to 8 bytes, and then append 0000 00FF FE00 (i.e., 14 bytes total) | |
| 1000nnnn | Append 0b0000nnnn+2 bytes of zeroes | |
| 1001nnnn | reserved | |
| 101nssss | sa += 0b0ssss000, na += 0b0000n000 | |
| 11nnnkkk | n = na+0b00000nnn+2; s = 0b00000kkk+sa+n; append n bytes from previously output bytes, starting s bytes to the left of the current output pointer; set sa = 0, na = 0 | |

# Example: ND Neighbor Solicitation

```
 Payload:
  87 00 a7 68 00 00 00 00 fe 80 00 00 00 00 00 00
  02 1c da ff fe 00 30 23 01 01 3b d3 00 00 00 00
  1f 02 00 00 00 00 00 06 00 1c da ff fe 00 20 24
Pseudoheader:
  20 02 0d b8 00 00 00 00 00 00 00 ff fe 00 3b d3
  fe 80 00 00 00 00 00 00 02 1c da ff fe 00 30 23
  00 00 00 30 00 00 00 3a
copy: 04 87 00 a7 68
4 nulls: 82
ref(32): fe 80 00 00 00 00 00 00 02 1c da ff fe 00 30 23
  -> ref 101nssss 1 2/11nnnkkk 6 0: b2 f0
copy: 04 01 01 3b d3
4 nulls: 82
copy: 02 1f 02
5 nulls: 83
copy: 02 06 00
ref(24): 1c da ff fe 00 -> ref 101nssss 0 2/11nnnkkk 3 3: a2 db
copy: 02 20 24
Compressed:
  04 87 00 a7 68 82 b2 f0 04 01 01 3b d3 82 02 1f
  02 83 02 06 00 a2 db 02 20 24
Was 48 bytes; compressed to 26 bytes, compression factor 1.85
```

# 79th IETF: 6lowpan WG Agenda

| | | | |
|---|---|---|---|
| 15:20 | Introduction, Agenda | Chairs | (10) |
| 15:30 | 1 – finishing ND | | |
| 15:30 | ND-14 | ZS | (15) |
| 15:45 | NCE/next-hop | SS | (15) |
| 16:00 | multihop DAD, context life | EN | (30) |
| 16:30 | Discussion | | |
| 17:10 | 3 – status security work | | |
| 17:20 | 0 – new work on HC | | |
| 17:25 | TCP HC | DR | (15) |
| 17:40 | Generic HC | CB | (10) |
| 17:50 | 0 – miscellaneous | Chairs | (5) |
| 17:55 | Next steps/Rechartering...18:10 | Chairs | (15) |

# Interesting individual submissions

- Split-off from ND:
  - draft-thubert-6lowpan-backbone-router-02.txt
    (to support LoWPANs with multiple border routers)
- Extensively discussed, limited usecase:
  - draft-thubert-6lowpan-simple-fragment-recovery-07.txt
    (special encapsulation with adaptation layer retransmit of individual fragments)

- For each of these, decide:
  - (A) We want to continue work as WG
  - (B) We encourage author to continue as individual submission
  - (C) We discourage further work

# 79th IETF: 6lowpan WG Agenda

| | | | |
|---|---|---|---|
| 15:20 | Introduction, Agenda | Chairs | (10) |
| 15:30 | 1 – finishing ND | | |
| 15:30 | ND-14 | ZS | (15) |
| 15:45 | NCE/next-hop | SS | (15) |
| 16:00 | multihop DAD, context life | EN | (30) |
| 16:30 | Discussion | | |
| 17:10 | 3 – status security work | | |
| 17:20 | 0 – new work on HC | | |
| 17:25 | TCP HC | DR | (15) |
| 17:40 | Generic HC | CB | (10) |
| 17:50 | 0 – miscellaneous | Chairs | (5) |
| 17:55 | Next steps/Rechartering...18:10 | Chairs | (15) |

# Securing 6LoWPAN ND

- 6LoWPAN ND is not secure and subject to attacks, it needs to be secured
- Secure 6LoWPAN ND can not use SeND directly because SeND uses computationally heavy cryprographical algorithms, etc.
- Simple extension to SeND (RFC 3971 & 3972) is needed
  - Use Elliptic Curve Cryptography public keys
  - Use SHA-2
  - Use efficient design