IPv6 over Low power WPAN WG (6lowpan)

Chairs:

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- **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 Optimizations (PS)**
- **Dec 2008 x 5 Use Cases (Info)**

Also: running documents for implementers, ~~interop~~

80th IETF: 6lowpan WG Agenda

15:20	Introduction, Agenda	Chairs	(10)
15:30	1 – ND WGLC results	ZS	(20)
15:50	0 – new work (individual drafts)		
15:50	Generic HC	CB	(10)
16:00	6LoWPAN proxy	LM	(10)
16:10	6LoWPAN for BT-LE	JN	(10)
16:20	6LoWPAN gw considerations	ZC	(10)
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17:00	retire		

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

draft-ietf-6lowpan-nd-15

Zach Shelby, Samita Chakrabarti, Erik Nordmark

Current status

- First WGLC in Sept/Oct, resulted in nd-14
- nd-15 was released in December
- Several interops have been held between multiple vendors using nd-14 and nd-15
- Second WGLC closed March 3rd
- The result?
  – 5 technical change requests identified
  – Several sets of editorial comments (thanks!)

1. Unlimited ARO Lifetime

- Request from Anders Brandt
  - Could ARO lifetime have an infinite lifetime?
  - Use-case: Sensor that sleeps for weeks and weeks
- nd-15 already gives a maximum value of 40+ days!

```
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 = 2   |    Status     |   Reserved    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Reserved            |     Registration Lifetime     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
+                            EUI-64                             +
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

"Registration Lifetime: 16-bit unsigned integer. The amount of time in a unit of 60 seconds that the router should retain the Neighbor Cache entry for the sender of the NS that includes this option. "

2. Capabilities Option for GHC

- draft-bormann-6lowpan-ghc-02 defines a generic header compression for 6lowpan
- Requires that a node knows which neighbors support GHC a priori to use it
- How to bootstrap this?
- Proposes a new 6LoWPAN Capability Indication (6CIO)
  - Included in the RS to indicate capability
- We suggest defining this in a separate draft

3. Setting L-bit on Transitive Links

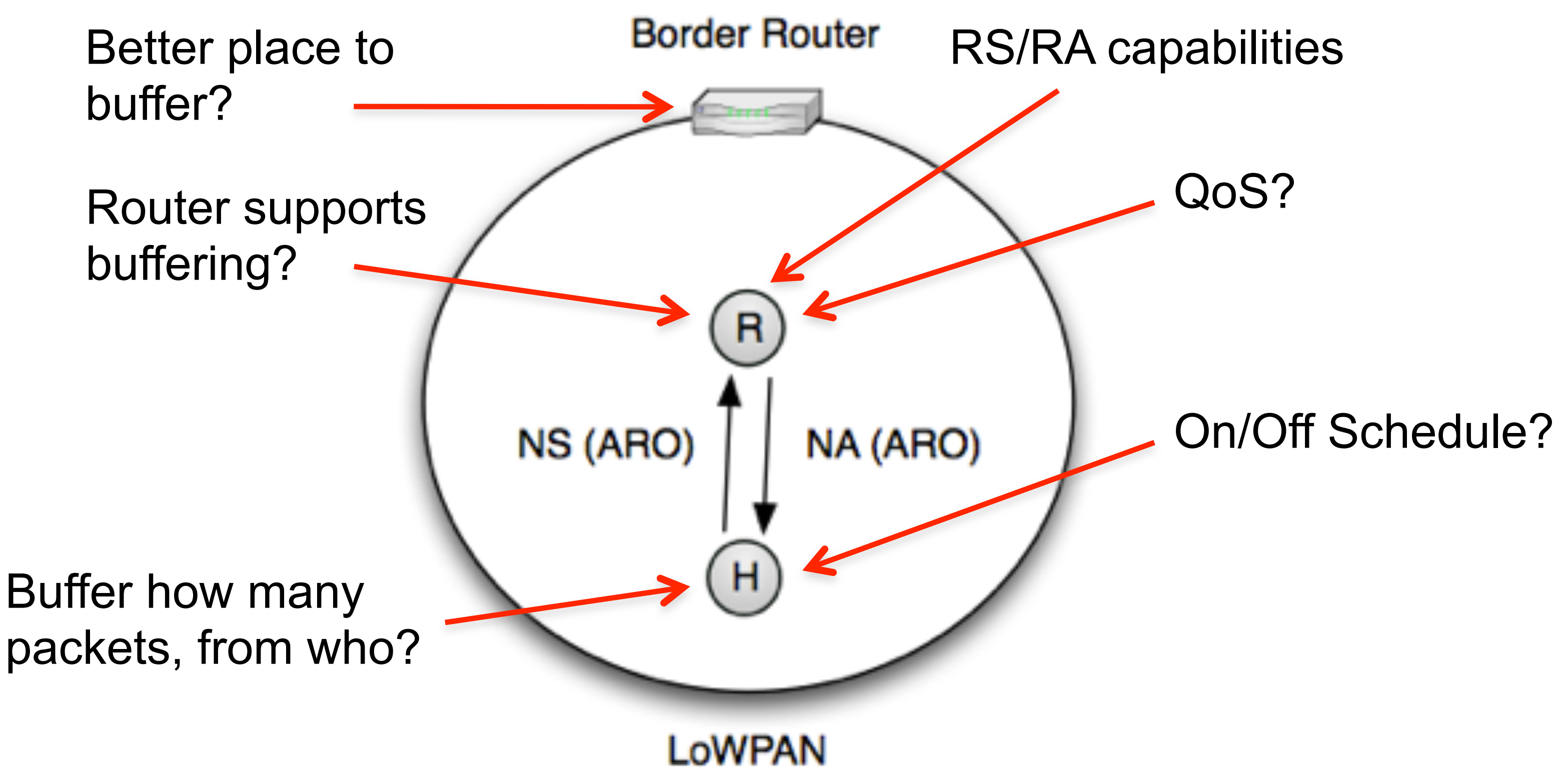
- Request from Pascal Thubert
- nd-15 currently requires the L-bit (on-link) to always be unset
- On mesh-under and non-transitive links with sleeping nodes (LLNs) this makes sense
- ND registration model could be useful also on transitive links, but…
- Use of all/some of ND optimizations outside of LLNs needs to be specified elsewhere
- Ticket: Add text to applicability section

4. Explicit Registration Bit in PIO

- Request from Pascal Thubert
- How does a node know if it should register an address with a router?
- nd-15 assumes LLNs are always uniform
  - Everyone on a LoWPAN implements these ND optimizations
- We have explicit L and M bits in the RA
- Do we need an explicit “register” bit in PIO?
- Conclusion – an LLN does not, such a capability could be defined elsewhere, e.g. the GHC capabilities option

5. Sleeping Node Buffering

- “Buffer for me” ARO bit requested by several people



Editorial Comments

- Alignment of the assumption & goal bullet points
  - Update bullet point on losing connectivity
  - Update optimization bullet point
  - Remove “minimize complexity” bullet point as this is obvious
- Open NCE acronym in Section 3.5, pointer to RFC4861
- Bracket bug to be fixed in Section 8.2

Next Steps

- Close our WGLC tickets
  - Applicability text on use of ND optimization outside of LLNs
  - Editorial improvements
- Done

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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
```

Capability Indication (new in -02)

- How does a node know another node speaks GHC?
- Add 6LoWPAN Capability Indication (6CIO) option in ND:

```
 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 = 1  |_____________________________|G|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|_______________________________________________________________|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

- Typically only needed on initial RS
  - implicit indication takes it from there
- Option could be used for future other capability indications

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Guidelines for the Operation of a 6LoWPAN-ND Proxy Gateway
-
draft-maqueda-6lowpan-pgw-00

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Sen.se - Paris, France

March 28, 2011

Outline

What is a 6LP-GW?

Definition: A 6LP-GW is the logic in charge of performing the following operations:

- Forwarding between IEEE 802.15.4 and IEEE 802.3 segments
- **Proxy** mechanisms between IPv6-ND and 6lowpan-nd
- Optimize certain tasks

Why do we need a 6LP-GW? (1)

Objective: We want to **integrate** a 6LoWPAN network into an **existing** IPv6 network.

- We need an IEEE 802.15.4 access point
- We need support for 6LoWPAN
- We need IPv6 router functionality

Why do we need a 6LP-GW? (2)

Integrating IEEE 802.15.4 and IEEE 802.3 segments into the same IPv6 subnet is not that easy:

- ND protocol has link-local scope
- Our link now has two different Neighbor Discovery protocols:
  - 6lowpan-nd
  - Neighbor Discovery for IPv6
- These two protocols happen to be incompatible

How does a 6LP-GW work?

Operation at two different levels:

- Packet forwarding & link-layer address translation
  - Link-layer address translation
  - 6LoWPAN Adaptation layer tasks
    - Compression/decompression
    - Fragmentation/reassembly
  - ICMPv6-level link-layer address translation
- ND-proxy mechanisms

ND proxy mechanisms: Overview (1)

Proxy between 6lowpan-nd and traditional IPv6-ND (draft-maqueda-6lowpan-pgw-00)

- From the 6LoWPAN side, the 6LP-GW together with the IPv6 router are seen as 6LBR
  - A 6LP-GW MUST implement most of the 6LBR functionality:
    - Address Registration
    - Context Configuration and Management
    - etc.
- From the Ethernet side, 6LNs are seen as simple FFDs
  - A 6LP-GW MUST provide functionality not present in 6lowpan-nd:
    - Address Resolution
    - DAD
    - etc.

ND proxy mechanisms: Overview (3)

The IPv6 Router + 6LP-GW set is seen as a 6LBR by 6LNs while 6LNs are seen as FFDs by other FFDs

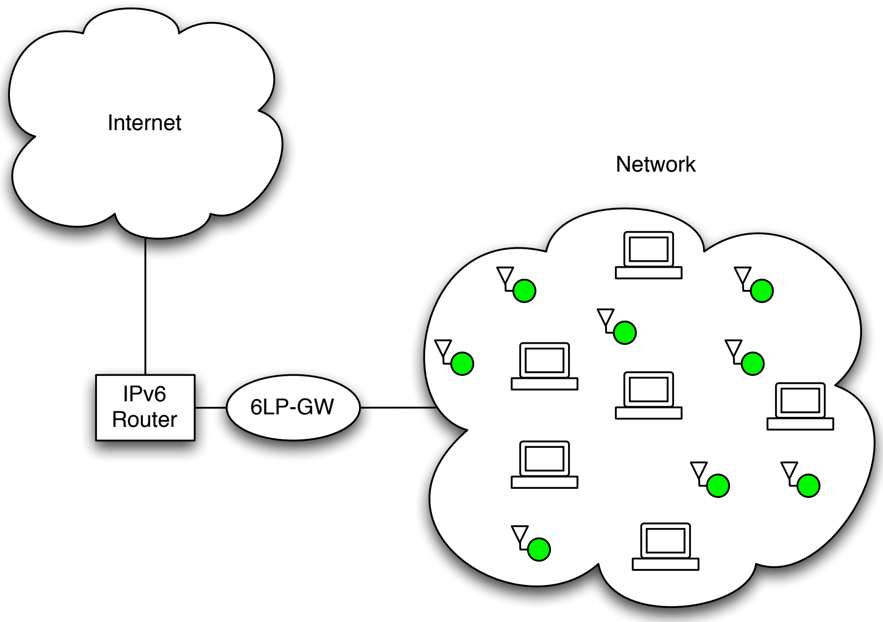

Figure 1: 6LP-GW + IPv6 Router

ND proxy operation examples

- Address Registration
- Address Registration (renewal)
- Address Resolution
- DAD (RFC 4861)

ND proxy operation: Address Registration (1)

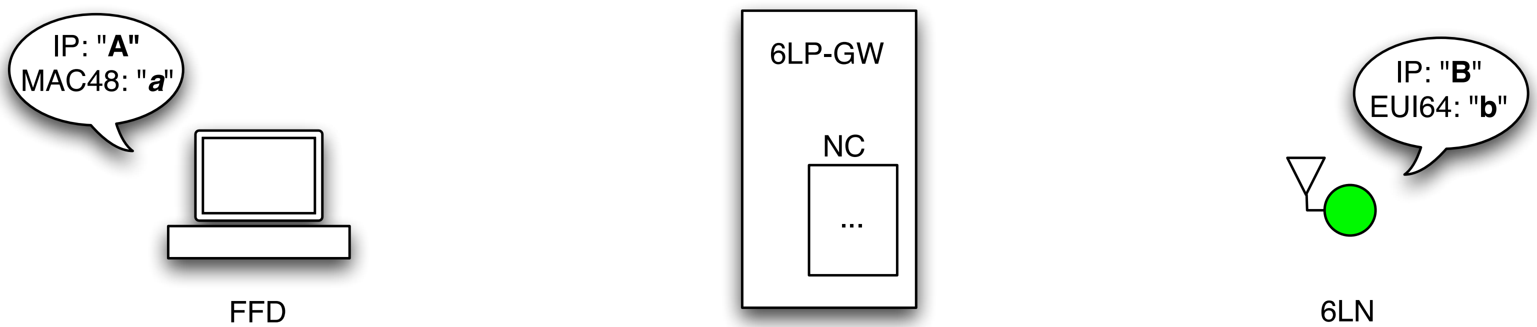

Figure 2: Initial situation

ND proxy operation: Address Registration (2)

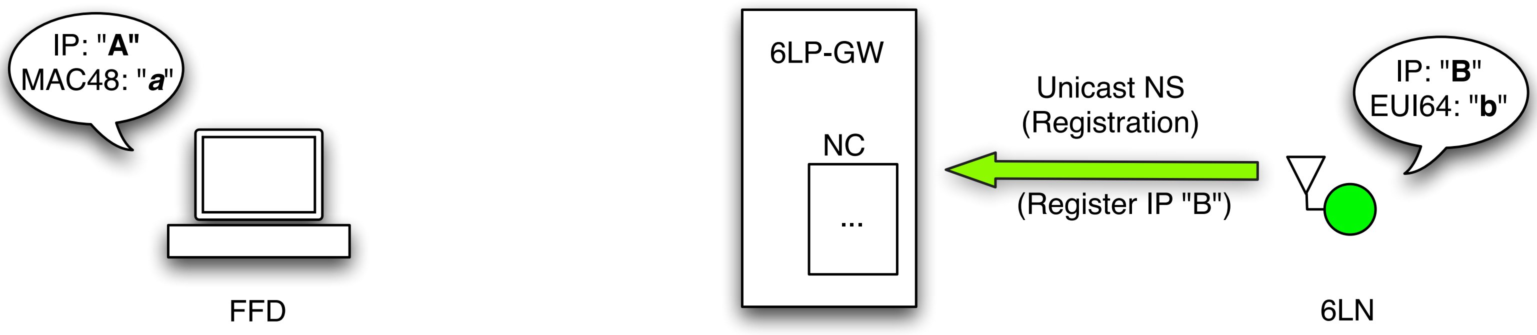

Figure 3: 6LN sends NS for Address Registration (including ARO)

ND proxy operation: Address Registration (3)

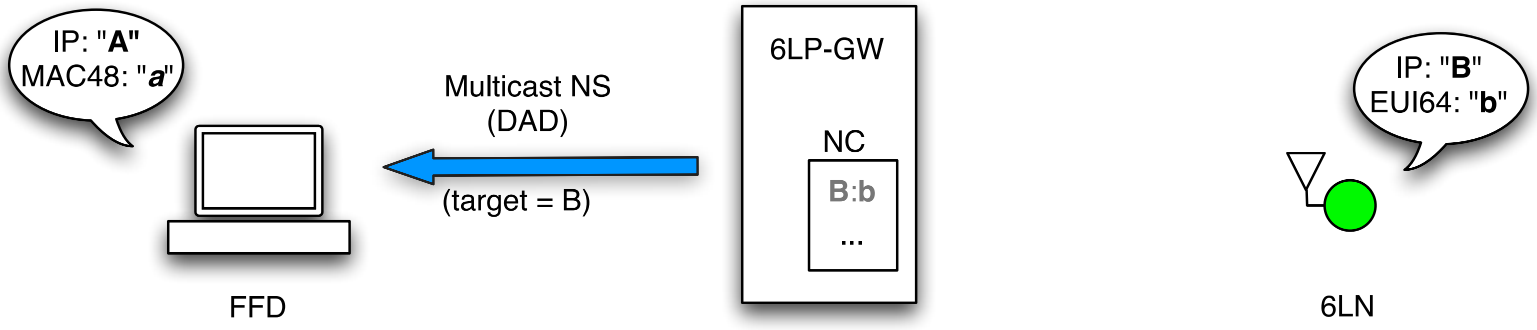

Figure 4: 6LP-GW sends NS for DAD in the IEEE 802.3 segment

ND proxy operation: Address Registration (4)

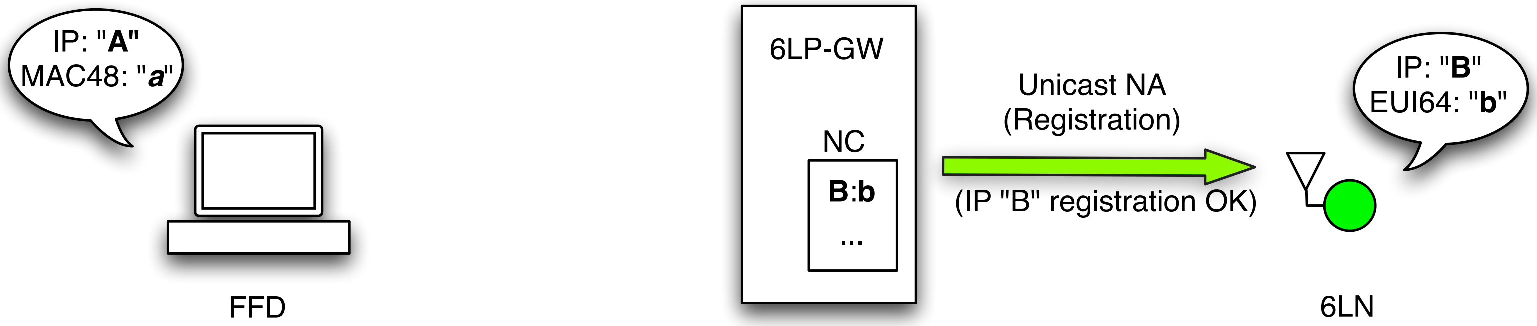

Figure 5: 6LP-GW sends NA reporting the registration status to the 6LN

ND proxy operation: Address Registration (renewal) (1)

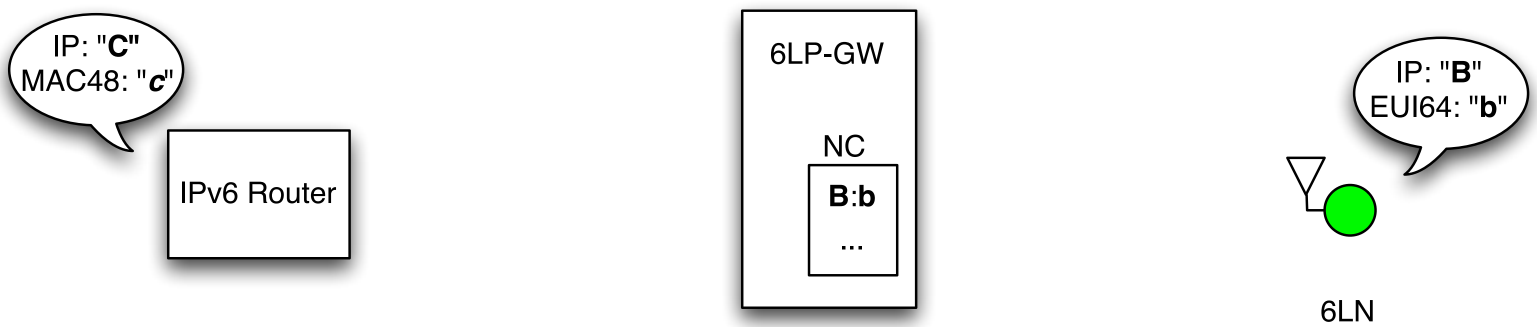

Figure 6: Initial situation

ND proxy operation: Address Registration (renewal) (2)

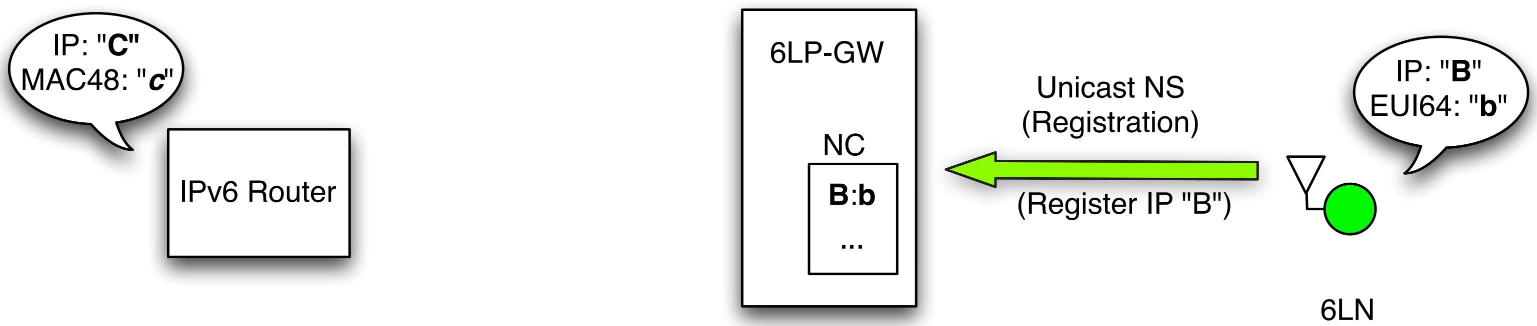

Figure 7: 6LN sends NS for Address Registration (including ARO)

ND proxy operation: Address Registration (renewal) (3)

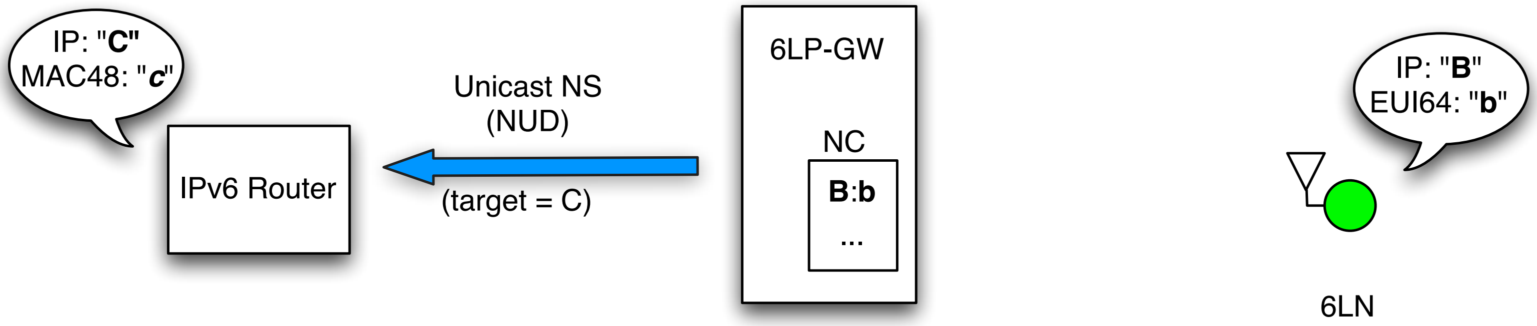

Figure 8: 6LP-GW forwards NS for NUD to the IPv6 router in the IEEE 802.3 segment

ND proxy operation: Address Registration (renewal) (4)

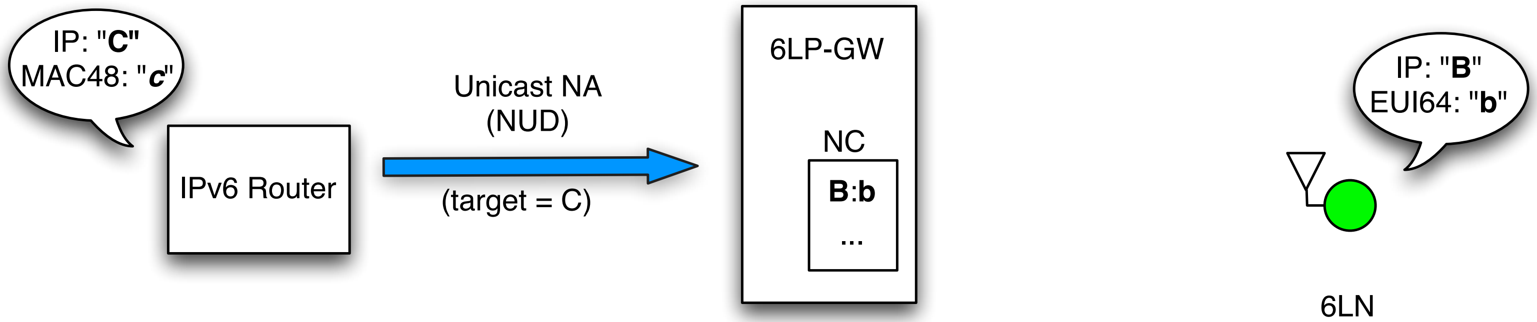

Figure 9: The IPv6 router responds with a unicast NA

ND proxy operation: Address Registration (renewal) (5)

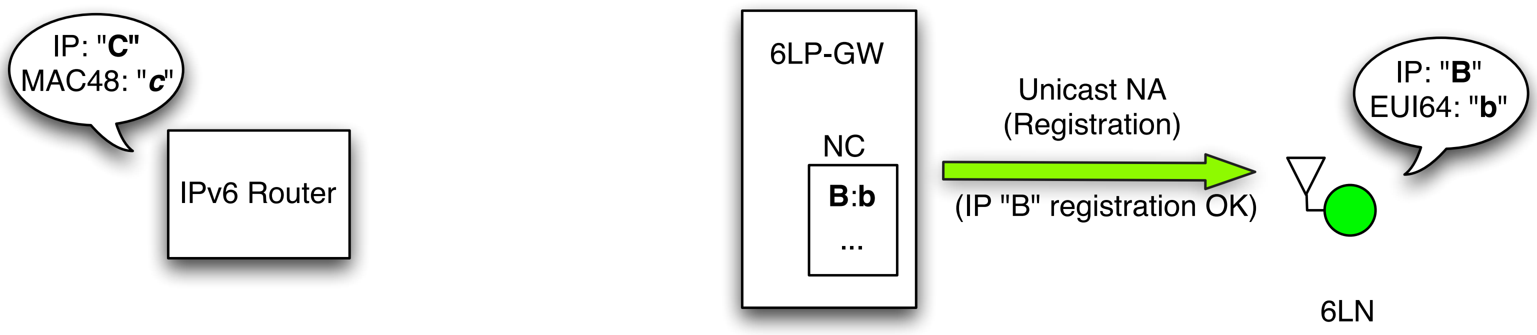

Figure 10: 6LP-GW forwards the NA to the 6LN, appending the corresponding ARO

ND proxy operation: Address Resolution (1)

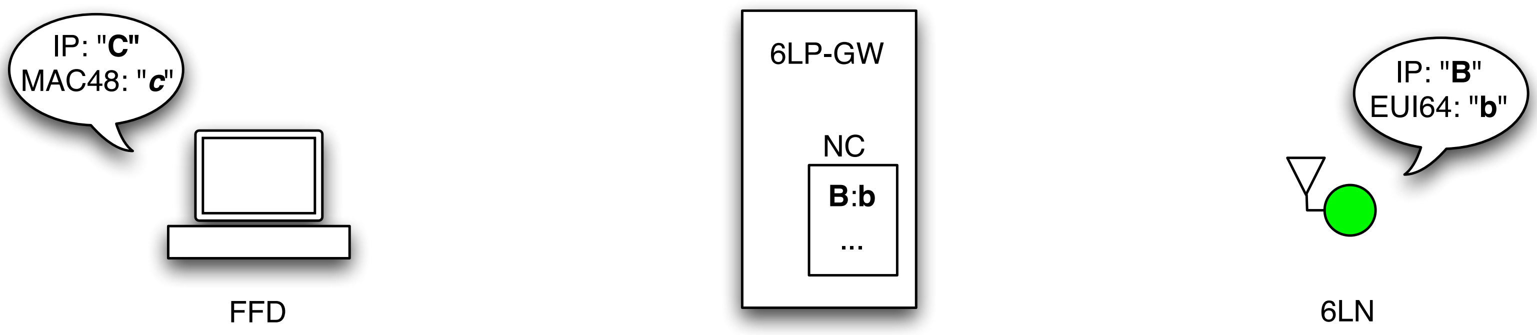

Figure 11: Initial situation

ND proxy operation: Address Resolution (2)

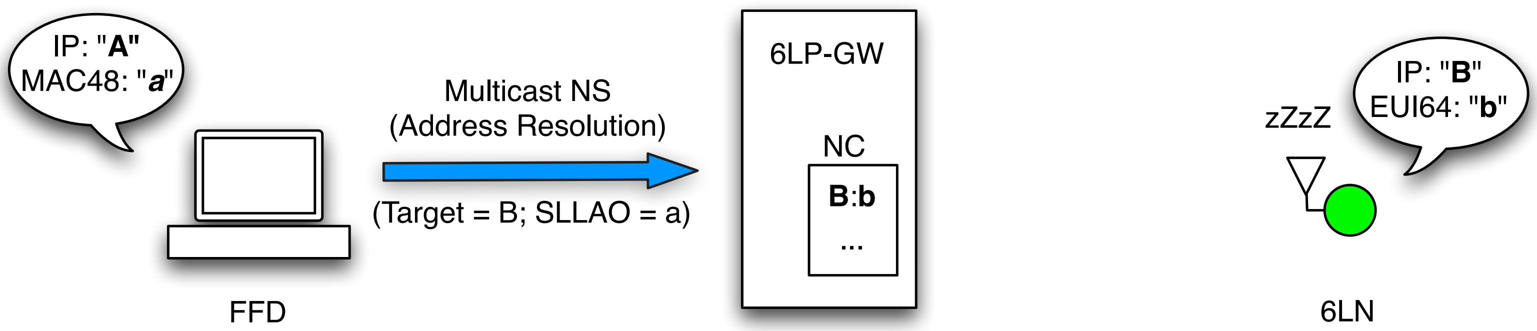

Figure 12: FFD sends NS for address resolution

ND proxy operation: Address Resolution (3)

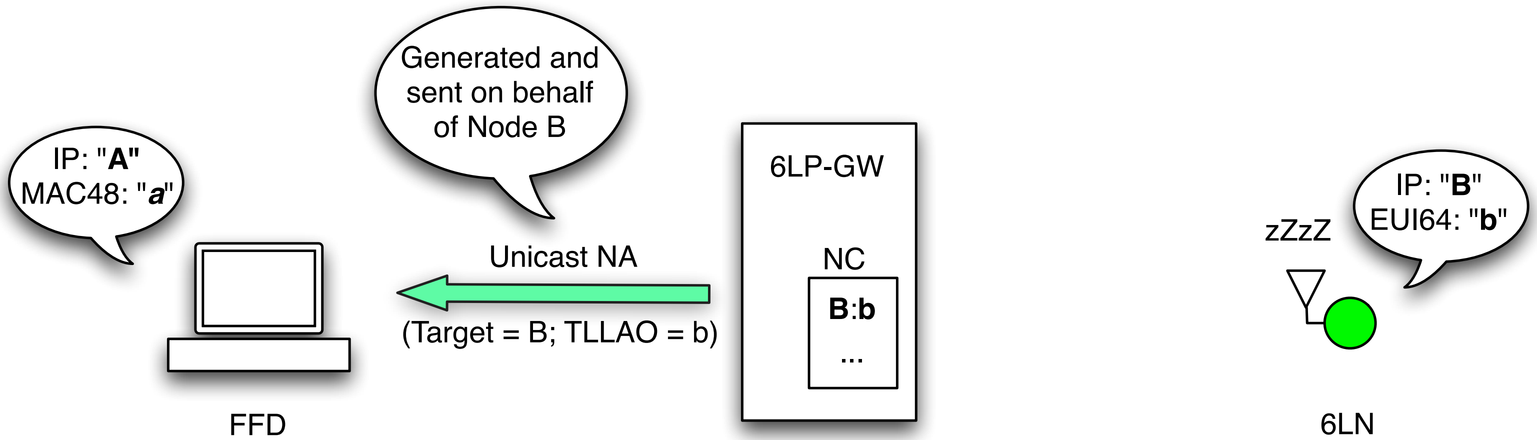

Figure 13: The 6LP-GW responds to the NS with a NA on behalf of the 6LN

ND proxy operation: DAD (1)

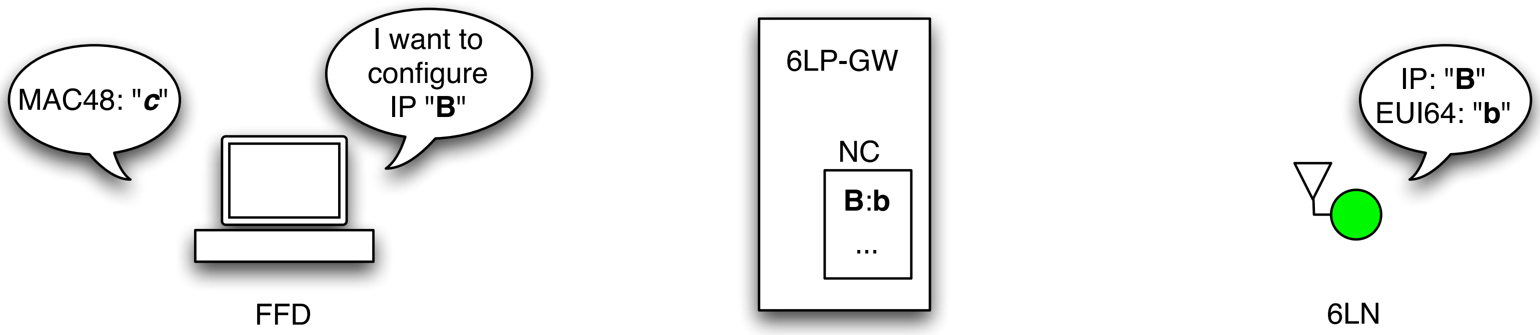

Figure 14: FFD wants to configure an address already in use by a 6LN

ND proxy operation: DAD (2)

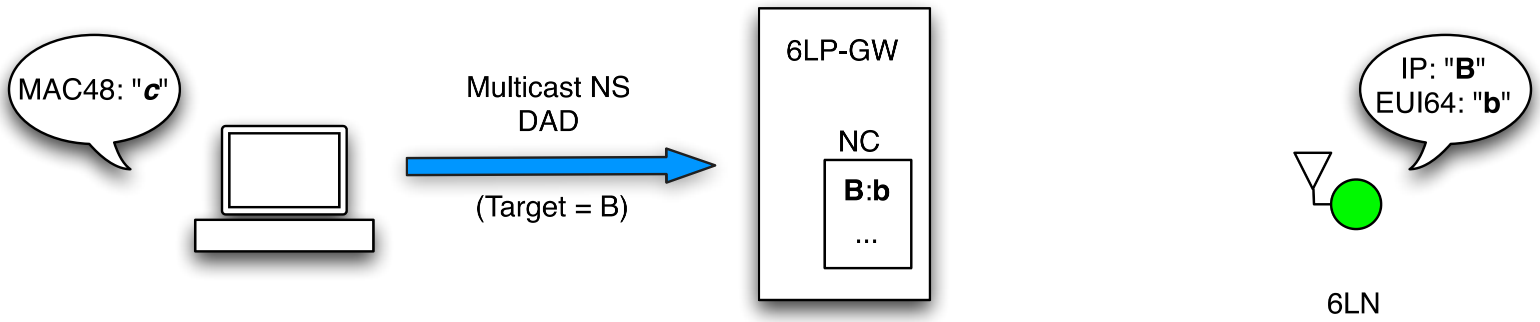

Figure 15: FFD sends a multicast NS for DAD

ND proxy operation: DAD (3)

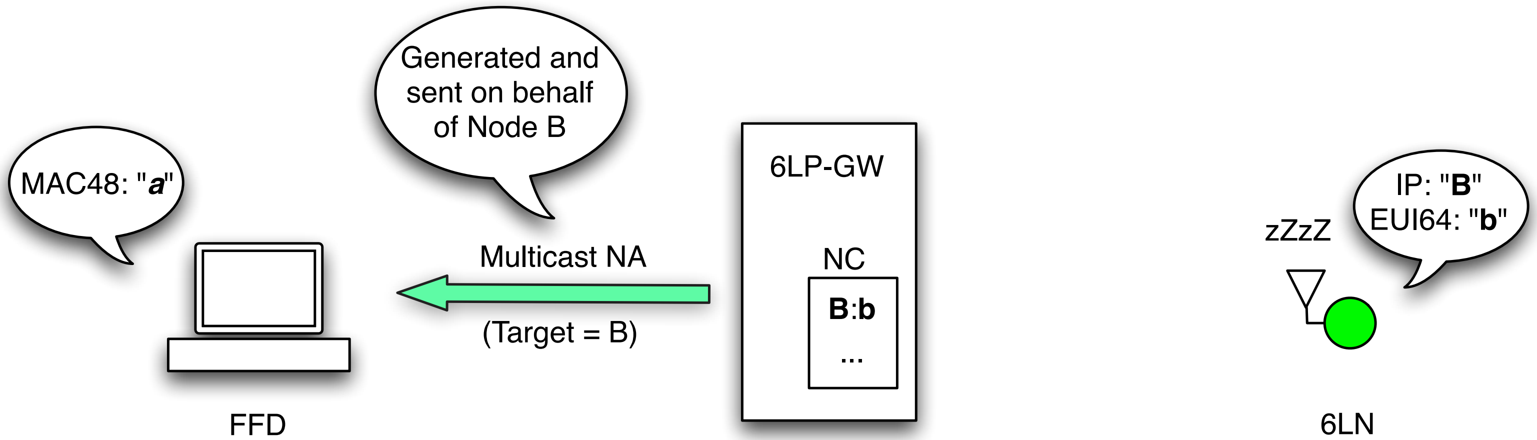

Figure 16: The 6LP-GW responds with a NA indicating that the address is in use

Conclusions

- Existing 6LP-GW running code
  - Low cost
  - low complexity
- Useful as a transitory solution (simple & inexpensive)
  - As an analogy: IEEE 802.11 (WiFi) APs were introduced long before WiFi was integrated into home routers
- Eases the deployment of 6LoWPAN
- Can facilitate adoption of 6LoWPAN

Questions?

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Transmission of IPv6 Packets over Bluetooth Low Energy

I-D: draft-patil-6lowpan-v6over-btle-01

Authors: Basavaraj Patil, Teemu Savolainen, Johanna Nieminen, Markus Isomäki (Nokia)
Zach Shelby (Sensinode)

Bluetooth Low Energy Overview

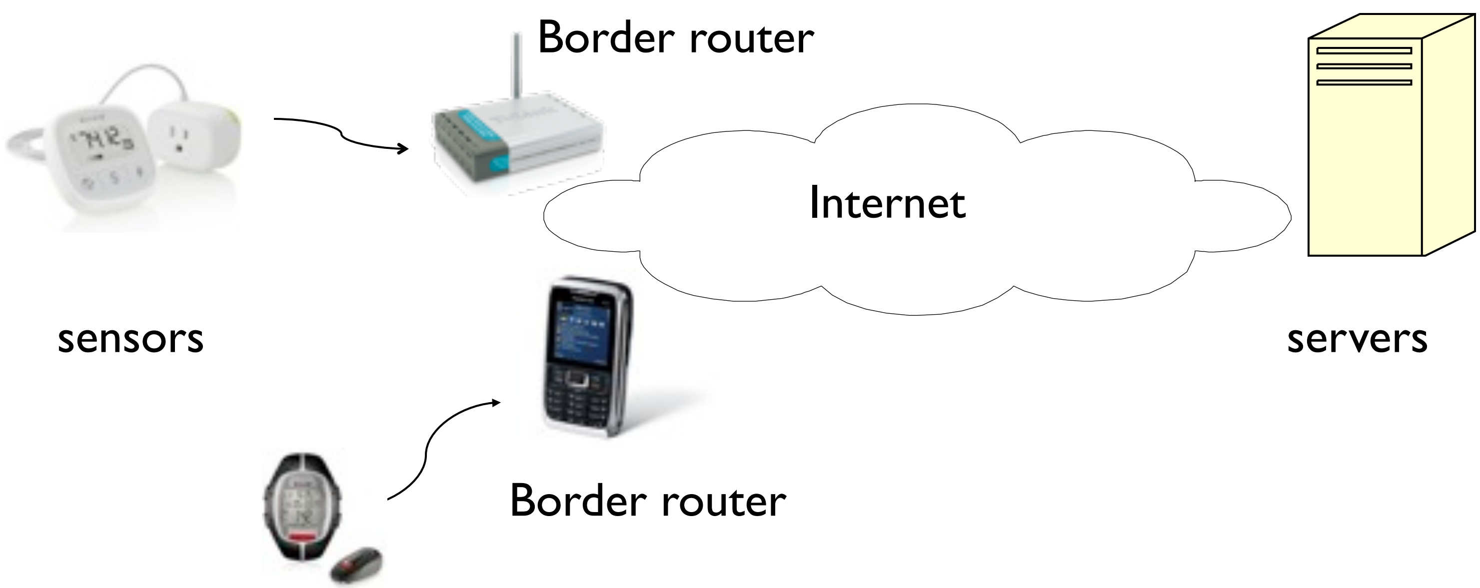
- Bluetooth Low Energy (BT-LE) is a new radio technology optimized for ultra low power
  - Operates on 2.4 GHz ISM band
  - Range ~50-100 m
  - Significant changes compared to classical Bluetooth in PHY, LL, protocol and application profiles
  - Enables accessories for sensors, smartphones, appliances etc.

Market Insights

- BT-LE is expected to appear in billions of devices and sensors in the next few years
  - BT-LE will be available in almost every mobile phone that supports BT
- Connecting BT-LE sensors to the Internet will
  - enable new types of use-cases and applications
  - enhance the operation of existing use-cases

IPv6 over BT-LE

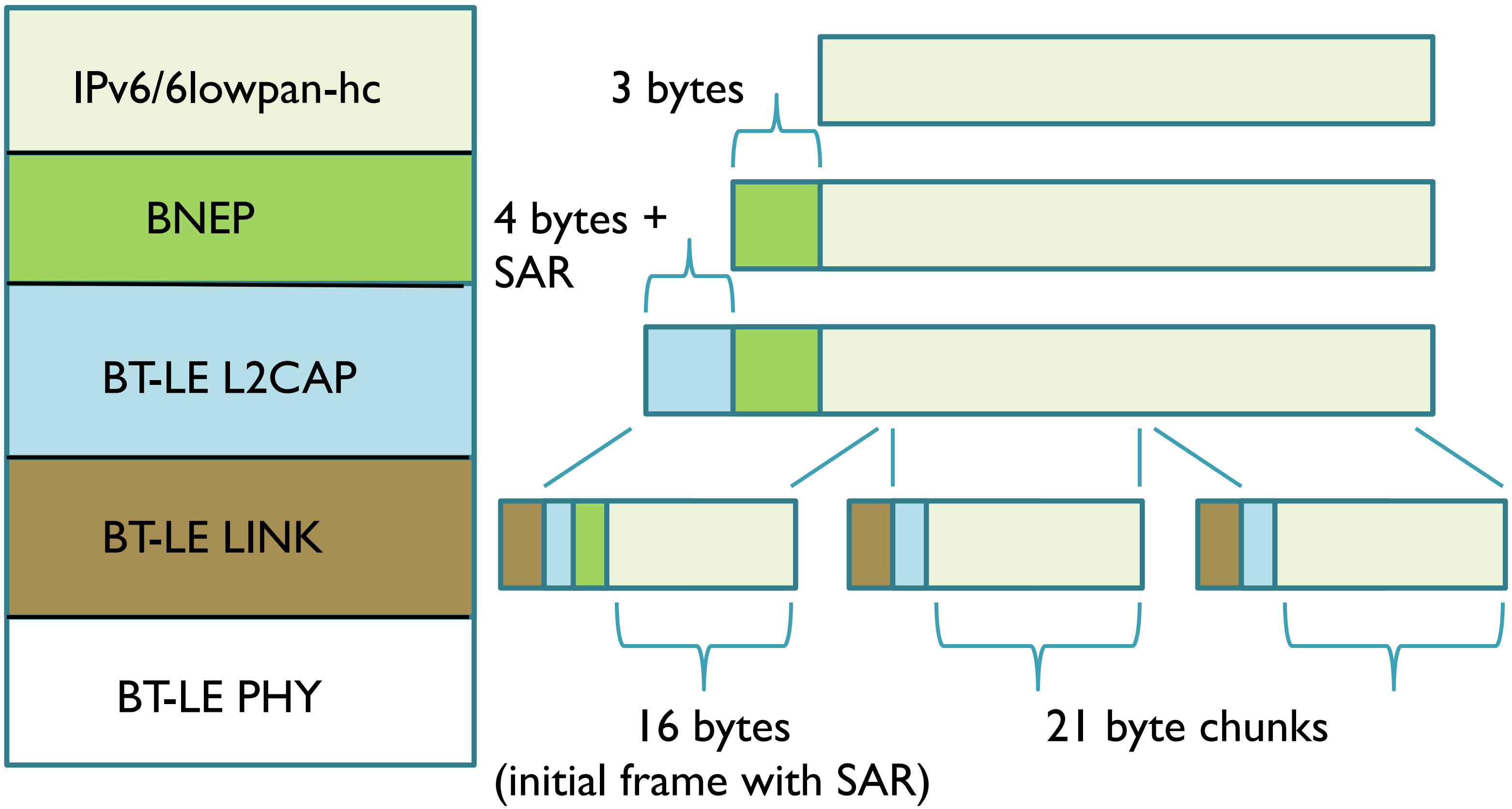
- Solution for IPv6 over Wireless PAN (6lowpan) has been specified for 802.15.4
- BT-LE is a new low power air-I/F with wide applicability
  - Need to specify IPv6 over BT-LE



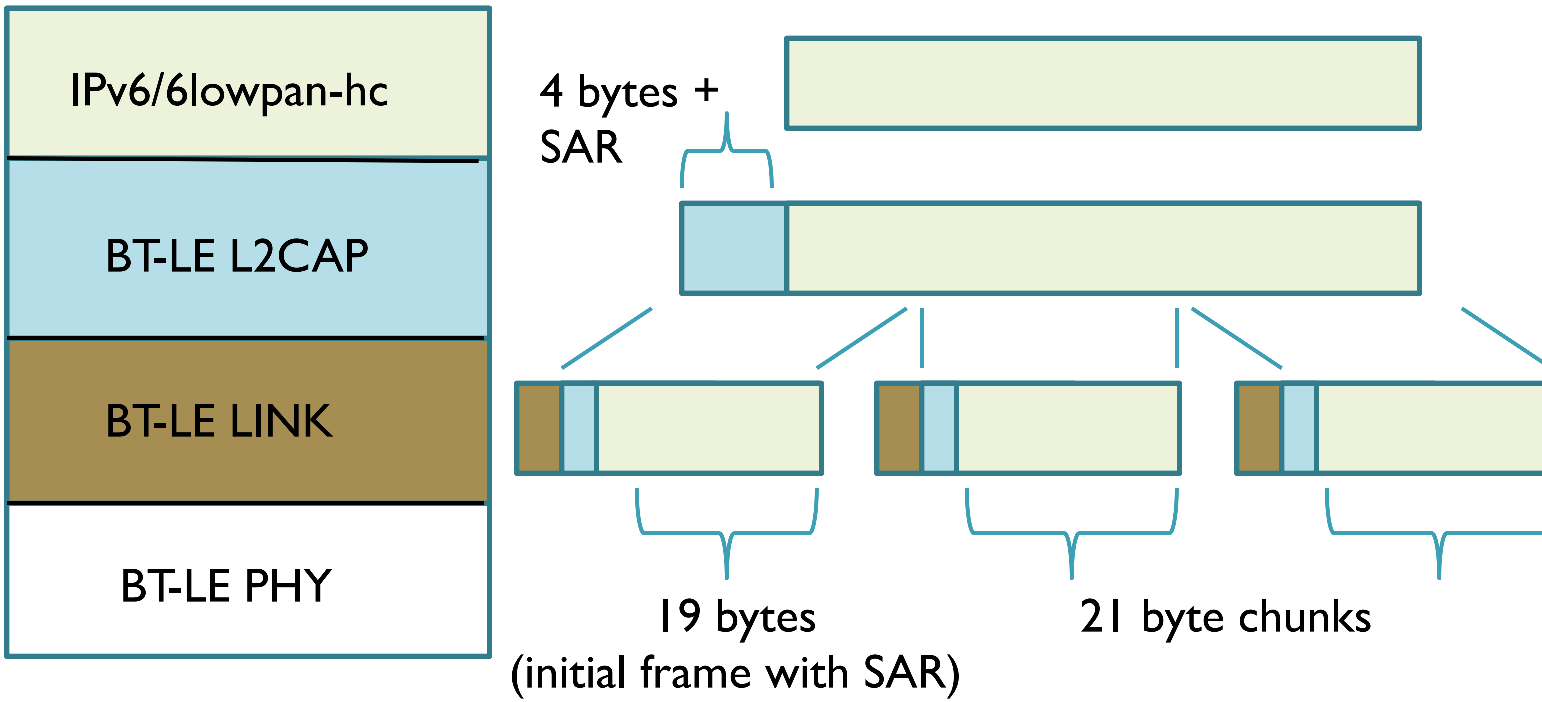
6Lowpan applicability to BT-LE

- BT-LE does Segmentation and Reassembly at the L2CAP layer
  - No need to implement SAR in the 6Lowpan adaptation layer
- BT-LE operates on a star topology
  - No need for mesh headers or all details of neighbor discovery
- Simply compress IPv6 protocol with HC1 header format
  - BNEP can be optionally used between compressed IPv6 and BT-LE L2CAP

Resulting protocol stack



Or alternatively



Next steps

- Adopt this work as 6lowpan WG item?

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6Lowpan Gateway Consideration

-- How could we connect 6Lowpan with not IPv6 ready Internet?

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March 29, 2011
Prague, CZ

Problems

- The ultimately goal of enabling IPv6 stack on small devices is to connect them to the global Internet.
- However the connection from the gateway to the outside network is still evolving to the IPv6;
  - Many parts of the network is still IPv4, especially for home users
  - And many Internet application servers are not IPv6 ready
- IETF has developed many transition techniques, but how to use them in for the IPv6 smart network

Net Architecture

```
                                                     +---------+
                                                     | Server  |
   O                                                 +---------+
  / \                                     +-------+       |
 /   \     +---+    /_______\   +------+ /         \      |
OIPv6 O----|SNG|---+ Access  +-| ONG  |--/ Internet  \------+
 \   /     +---+    \ Netw  /   +------+ \           /
  \ /                +------+             \         /
   O                                       +-------+
  Node
```

- Node: IPv6 ready sensors
- SNG: Smart Network Gateway
- ONG: Operator Network Gateway
- Server: Dual stack, IPv6 or IPv4

Aggregated Smart Network Gateways

- SNG aggregates the information collected from the smart devices and sends the aggregated message to the service platform
  - Pros: does not matter which IP is used, easy for data aggregation
  - Cons: not scalable, re-development for new services

Tunneling IPv6

```
                                                     +---------+
                                                     |  Server |
   O                                                 +---------+
  / \                ________            +-------+       |
 /   \      +----+  /        \  +------+  /         \      |
OIPv6 O-----|SNG|---+ Access  +-| ONG |--/ Internet \------+
 \   /      +----+  \ Netw   /  +------+ \           /     |
  \ /         |      +------+     |      \         /      |
   O          |                   |       +-------+       |
  Node        |                   |                       |
     IPv6     | IPv6 in IPv4      |     IPv6              |
-------------|====================|----------------------|
```

- Pros: can survive in IPv4 only access network
- Cons: server should support IPv6 or dual stack

IP Family Translation -1
Translating on ONG

```
                                                     +---------+
                                                     | Server  |
   O                                                 +---------+
  / \                _______              +-------+       |
 /   \     +----+   /       \  +------+  /        \       |
OIPv6 O----|SNG|---+ Access  +-| ONG |--/ Internet \------+
 \   /     +----+   \ Netw  /  +------+ \          /      |
  \ /        |       +------+     |      \        /       |
   O         |                    |       +-------+       |
  Node       |                    |                       |
             | IPv6 in IPv4       |       IPv4            |
|---IPv6-----|====================|-----------------------|
```

- Pros: support IPv4 only servers
- Cons: ONG should be deployed as a carrier grade device

IP Family Translation - 2

```
                                                     +---------+
                                                     | Server  |
   O                                                 +---------+
  / \                ________             +-------+      |
 /   \     +----+   /        \  +------+   /         \     |
OIPv6 O----|SNG|---+ Access  +-| ONG  |--/ Internet \------+
 \   /     +----+   \ Netw   /  +------+  \           /    |
  \ /        |       +------+      |       \         /     |
   O         |                     |        +-------+      |
  Node       |                     |                       |
             |         IPv4        |        IPv4           |
----IPv6-----|-------------------------------------------|
```

- Prons: support of IPv4 only services
- Cons: SNG should support translation, a bit heavy requirement?

Thank you

- Questions?

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16:40	New Work / Closing	Chairs	(10)
17:00	retire		

draft-bormann-6lowpan-roadmap

Carsten Bormann <cabo@tzi.org>
IETF80, 2011-03-28

Background

- Complex protocols need:
  - interpretations/clarifications
  - small fixes
  - roadmaps (how does everything fit)

- Role model: RFC 4815
  - draft-ietf-rohc-rtp-impl-guide
  - Started in 2002, went through 23 versions
  - RFC in 2007

Roadmap for 6LoWPAN

- Which documents are needed to make a "6LoWPAN"? (RFC 4944, HC-15, ND-15)
- What is defined in a confusing or misleading way by this set of documents?
- What issues need to be fixed in a grander picture?

- "Non-Milestone" charter item of 6LoWPAN WG

Roadmap issue 1: MTU

- 6LoWPAN MTU was designed for stub networks
- Set at 1280 (the minimum IPv6 allows)
- This does not work with **RPL** (tunneling)

- Change: mandate a larger MTU where RPL is in use in tunneling mode (specify details)

Roadmap issue 2: PAN identifier

- RFC 4944 allows the use of PAN identifiers in interface IDs (IIDs) derived from 16-bit addresses
- This makes HC-15 less efficient
- Change: “Don’t do that, then”

Roadmap vs. LWIG WG

- Roadmap will stitch together and amend **normative specifications**
- Target: Standards Track
  - (unless obsoleted by fixing all base specs)
- **Not** focused on implementation techniques
- vs. Lightweight Implementation Guidance WG
- Techniques that should go into LWIG are e.g.:
  - 6LoWPAN Fragment forwarding
  - CoAP Token handling

LWIG technique 1: 6LoWPAN Fragment Forwarding Technique

- 6LoWPAN:
  adaptation layer fragmentation can be needed
- Route-Over happens above adaptation layer
- Would have to reassemble at each hop
- Better:
  - Build cache entry on initial fragment
  - Forward initial fragment immediately
  - Forward each non-initial fragment based on cached IP header info

LWIG technique 2: CoAP Token Handling (?)

- CoAP: Tokens used for request-response matching in non-piggybacked responses
- Needs space in packet and node
- Better:
  - Use default value of 0 while not pipelining
  - Use non-zero values (or separate port numbers) with multiple outstanding requests
  - Document the rules that can minimize space used on both ends

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Other drafts

- draft-cardenas-dff-00
- draft-daniel-6lowpan-security-analysis-05
- draft-kahng-6lowpan-global-connectivity-01
- draft-qiu-6lowpan-secure-router-01
- draft-sarikaya-6lowpan-cgand-00
- draft-singh-6lowpan-global-connectivity-00

Global connectivity for 6lowpan

Dhananjay Singh, Gohel Bakul Chandulal and Antonio Jara

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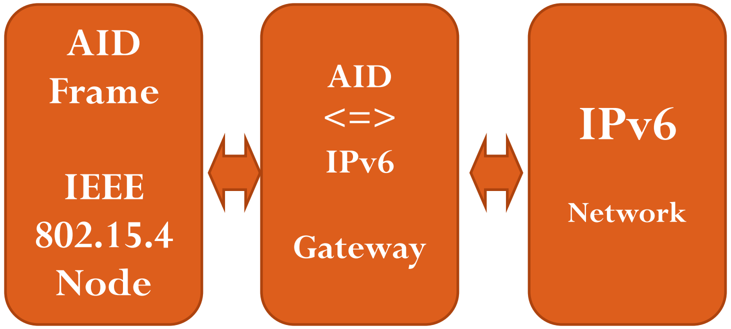
Global connectivity for 6lowpan

- Goal
  - Better IPv6 Header compression during Global Connectivity
- Current solution and problem
  - IPv6 Header compression scheme (HC1) [RFC 4944]
  - During global communication Destination IPv6 address remain Inline (uncompressed)
- Solution …!!
  - AID in place of 16 byte IPv6 address
  - AID and IPv6 translation at Gateway

- **AID** – adaptation Identifier, Short ID
- **IN-node:** a IEEE 802.15.4 node within the PAN (personal area network)
- **OUT-node:** Any node outside the PAN, connected with IN-node through IPv6 Domine



Global connectivity for 6lowpan

- Highlights
  - **Link layer address of IN-node should be present**
    - give identity to IN-node (Association)and if any error reply, back the message
  - **AID for OUT-Node only, NOT for IN-node**
    - Ipv6 address for IN-node generated through stateless auto configuration
  - **AID-IPv6 translation Table**
    - AID correspond with Link-layer address in AID-IPv6 translation Table

      it reduces the complexity of AID management while in mobility and PAN with multiple Gateway
  - **AID generation and mechanism**
    - AID generated by IN-node and Mechanism such a that maintain uniqueness of AID across the gateways during mobility and PAN with multiple gateways
  - **Mobility support**
    - AID management such a that support Mobility and Pan with Multiple Gateways

Comparison of AID based Global communication in 6lowpan

Work by Kahng et al. [2, 3]	*Work by Singh et al.*[4]
No information about presence of Link layer ID in AID frame	Link Layer ID should be present in AID packet
AID for IN-node	No need of AID for IN-node
No information on Mobility and multiple gateway support	Supports Mobility and multiple gateways
AID value generated by Gateway	AID value generated by In-node
No Link Layer ID in AID – IPv6 Translation Table	Link Layer ID in AID – IPv6 Translation Table , useful in mobility and multiple gateway
Lacks the complete format of Adaption Layer Header structure in AID based communication	complete format of Adaption Layer Header structure in AID based communication is given

References

1. G. Montenegro, N. Kushalnagar, J. Hui, D. Culler, "Transmission of IPv6 Packets over IEEE 802.15.4 Networks", RFC4944, September 2007.

2. Hyun K. Kahng, Dae-In, Choi, Suyeon, Kim "Global connectivity in 6LoWPAN" draft-kahng-6lowpan-global-connectivity-00.txt, October, 2010

3. Hyun K. Kahng, Dae-In, Choi, Suyeon, Kim "Global connectivity in 6LoWPAN" draft-kahng-6lowpan-global-connectivity-01.txt, March, 2011

4. Gohel B. and Singh D. "Global connectivity for 6lowpan" draft-singh-6lowpan-global-connectivity-00.txt, Feb 2011

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