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

Also: running documents for implementers, interop

75th IETF: 6lowpan WG Agenda

09:00	Introduction	Chairs	(5)
09:05	802.15.4e update	RS	(10)
09:15	2 – HC	JH	(15)
09:30	1 – ND	ZS	(40)
10:10	5 – Use cases	EK	(5)
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10:20	6 – Security		(10)
10:30	0 – Fragment Recovery	PT	(15)
10:45	0 – SNMP Opt	HM	(20)
11:05	0 – MIB	KK	(10)
11:15	6LowApp Pointer, Rechartering, Lunch		

What is 6lowpan?

- **Interesting L2 network: IEEE 802.15.4**
  - **Low power, 20..250 kbit/s, 900 and 2400 MHz**
  - **Almost, but not entirely, unlike 802**
    - Small MTU, limited range

ALMOST

- **Job of 6lowpan: make this look like an IPv6 link**
  - **Classical encapsulation issues → format document**
  - **Reachability: mesh routing**
    - can do route-over, too
  - **No multicast: emulate, avoid (e.g., ND)**

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Update on IEEE 802.15.4e

René Struik (Certicom Research)

IEEE 802.15.4e PAR Scope and Purpose

Scope:

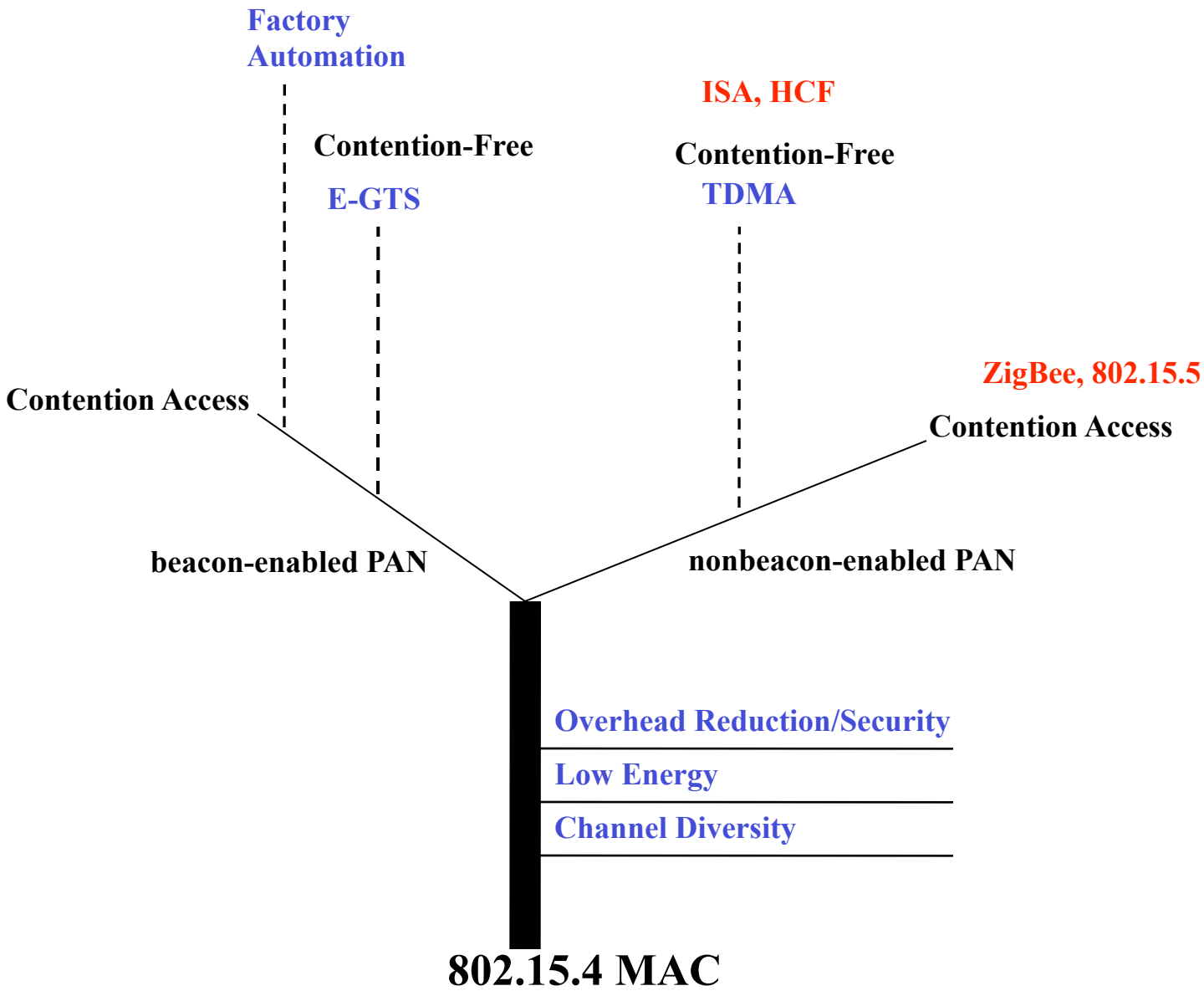
Amendment of 802.15.4-2006 MAC limited to

- TDMA: to provide a) determinism, b) enhanced utilization of bandwidth
- Channel Hopping: to provide additional robustness in high interfering environments and enhance coexistence with other wireless networks
- GTS: to increase its flexibility such as a) supporting peer to peer, b) the length of the slot, and c) number of slots
- CSMA: to improve throughput and reduce energy consumption
- Security: to add support for additional options such as asymmetrical keys
- Low latency: to reduce end to end delivery time such as needed for control applications

Purpose:

- Better support of industrial applications, including those addressed by HART 7, ISA100 proposed standards
- Compatible with enhancements defined by proposed Chinese WPAN standard that aren't included in 802.15.4c.

Amendment addresses coexistence with wireless protocols such as 802.11, 802.15.1, 802.15.3, and 802.15.4.


Factory Automation
ISA, HCF
Contention-Free
E-GTS
Contention-Free
TDMA
ZigBee, 802.15.5
Contention Access
Contention Access
beacon-enabled PAN
nonbeacon-enabled PAN
Overhead Reduction/Security
Low Energy
Channel Diversity
802.15.4 MAC

Documents

TG4e:

PAR & 5C: 07/859r1; July 2009 meeting report and timeline: 09/579r0

E-GTS:

proposals: 09/043r3, 09/377r4, 09/544r1; report: 09/183r2

TSCH:

proposals: 08/581r1, 09/582r1, 08/583r1, 09/067r0, 09/281r3; summary: 09/397r1

Factory Automation:

proposals: 08/572r0, 09/401r1, 09/566r2; report: 09/411r2

Channel Diversity:

proposals: 09/251r1

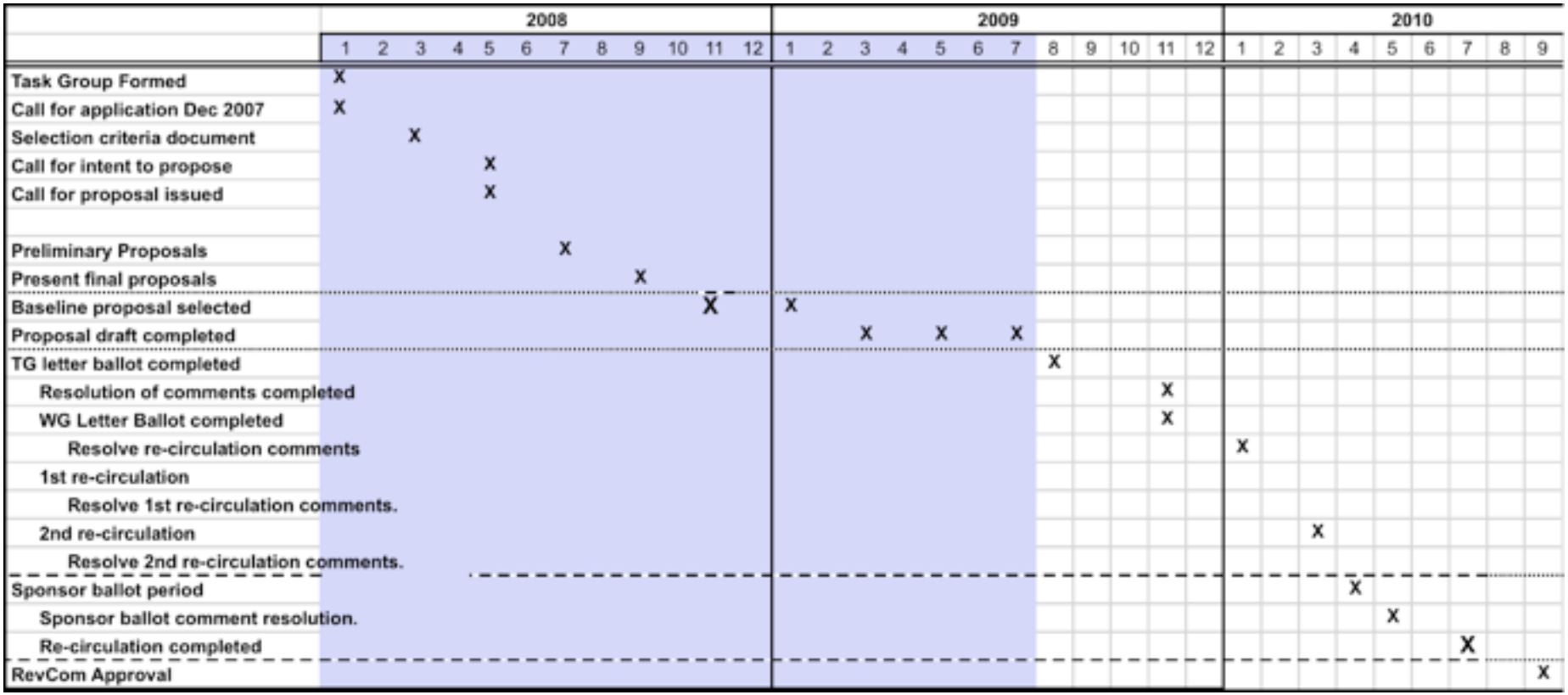
Overhead Reduction:

proposals: 08/828r9, 09/233r4, 08/848r1, 08/849r0; minutes: 09/265r5

Low Energy:

documents: 09/427r2, 09/544r1; reports: 09/523r2

Proposed TG4e Baseline Schedule

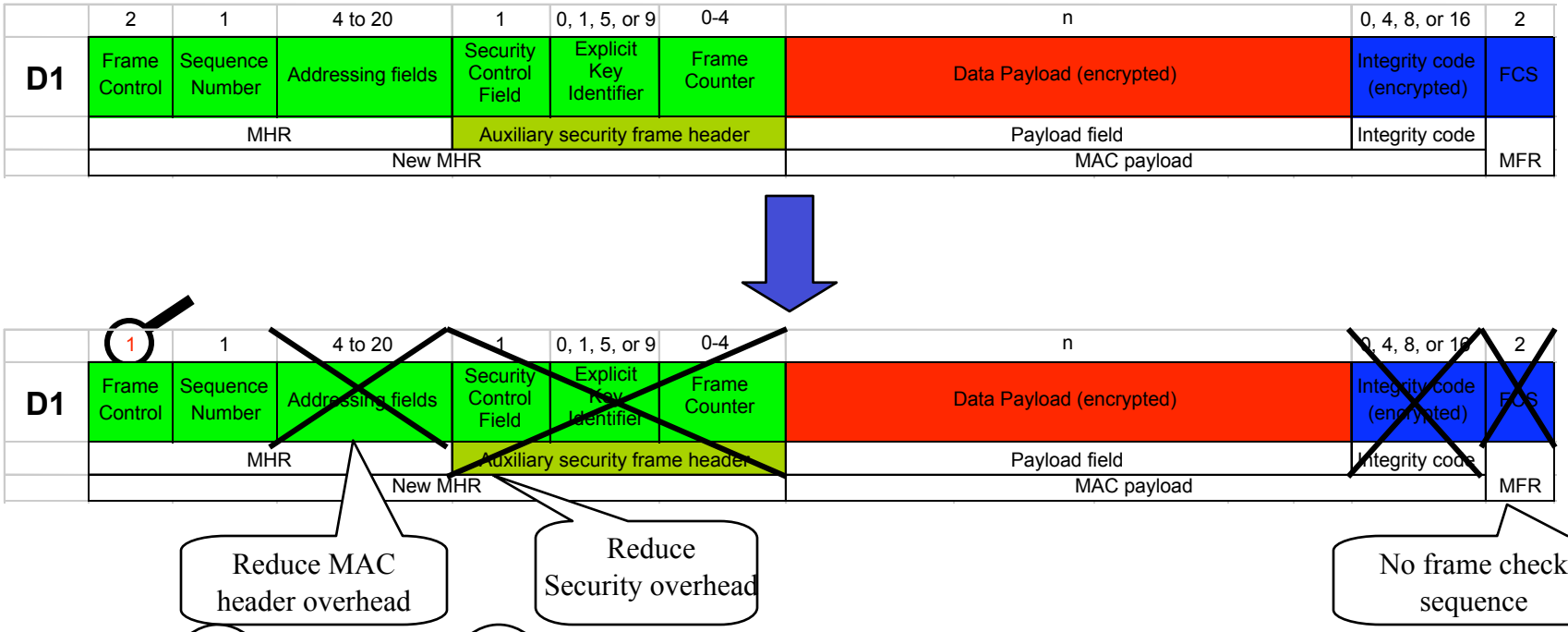


Next steps:

– August 15, 2009: pre-draft 802.15.4e with TBDs, to be informally reviewed

– November 2009: draft 802.15.4e ready for formal 802.15 WG ballot

Frame Formats (1)

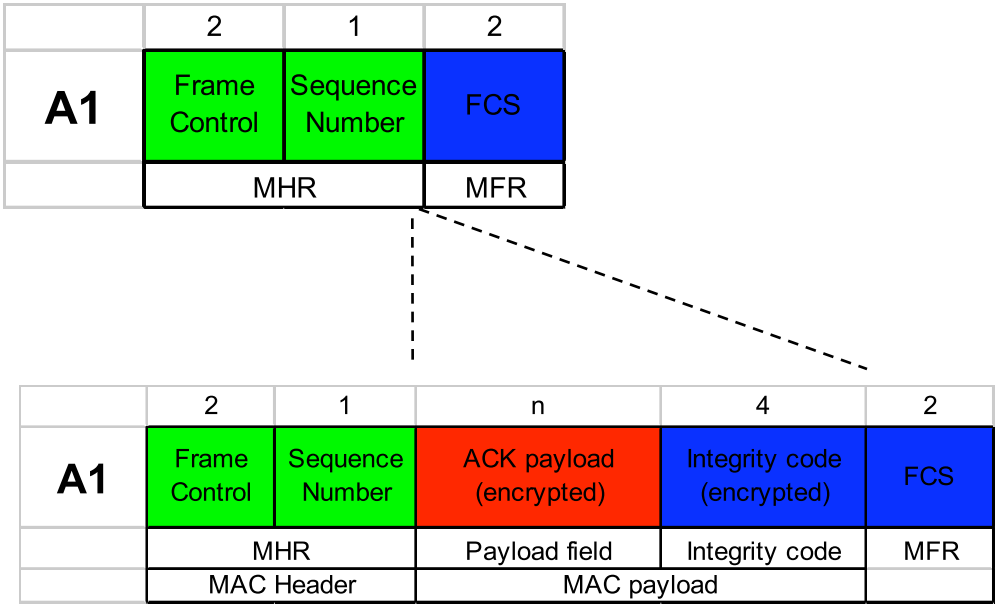


MAC payload	small	+CRC	+authenticity
5	7	9	13
6	8	10	14
7	9	11	15
8	10	12	16
9	11	13	17

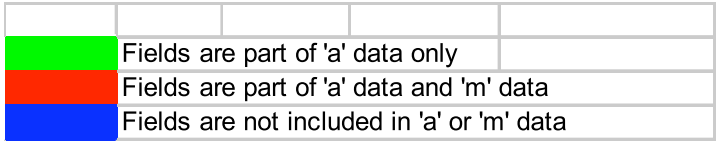
[1] with typical payloads

Fields are part of 'a' data only
Fields are part of 'a' data and 'm' data
Fields are not included in 'a' or 'm' data

Frame Formats (2)



(Idealized case)



Frame Formats (3)

FCF w/ 2006

bits: 0-1	2	3	4	5	6	7	8-9	10-11	12	13	14-15
Frame Type	sFCF=0	Security	Frame Pending	ACK request	PANId Compression	Frame version	Reserved	Dest. Addressing Mode	Reserved	Set to 1	Source Addressing Mode

NOTE: this FCF, as specified with 802.15.4-2006, has 3 reserved bits.

FCF

bits: 0-1	2	3	4	5	6	7	8-9	10-11	12	13	14-15
Frame Type	sFCF=0	Security	Frame Pending	ACK request	PANId Compression	Reserved	Reserved	Dest. Addressing Mode	Frame version	Set to 0	Source Addressing Mode

NOTE: this FCF also has 3 reserved bits! (i.e., "shifting" the version number does not come at cost)

sFCF

bits: 0-1	2	3	4	5	6	7
Frame Type	sFCF=1	Security	Frame Pending	ACK request	Reserved	Frame version

NOTE: this short FCF still has 1 reserved bit that may be used for other purposes.

ACK w/ sFCF

bits: 0-1	2	3	4	5	6	7
Frame Type	sFCF=1	Security	Reserved	Reserved	Reserved	Frame version

ACK w/FCF

NOTE: this short FCF for the ACK frame has 3 reserved bits that may be used for other purposes.

bits: 0-1	2	3	4	5	6	7	8-9	10-11	12	13	14-15
Frame Type	sFCF=0	Security	Ignored	Ignored	Ignored	Frame version	Reserved	Ignored	Ignored	Set to 1	Ignored

NOTE: this full FCF for the ACK frame has 10 reserved or ignored bits that may be used for other purposes.

Discussion

Current 6lowpan based on IEEE 802.15.4-2003

Time to move towards 802.15.4-2006 or even TG4e?

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Compression Format for IPv6 Datagrams in 6LoWPAN Networks

(draft-ietf-6lowpan-hc-05.txt)

Jonathan Hui
Pascal Thubert

6LoWPAN WG Meeting
75th IETF Meeting
San Francisco, California

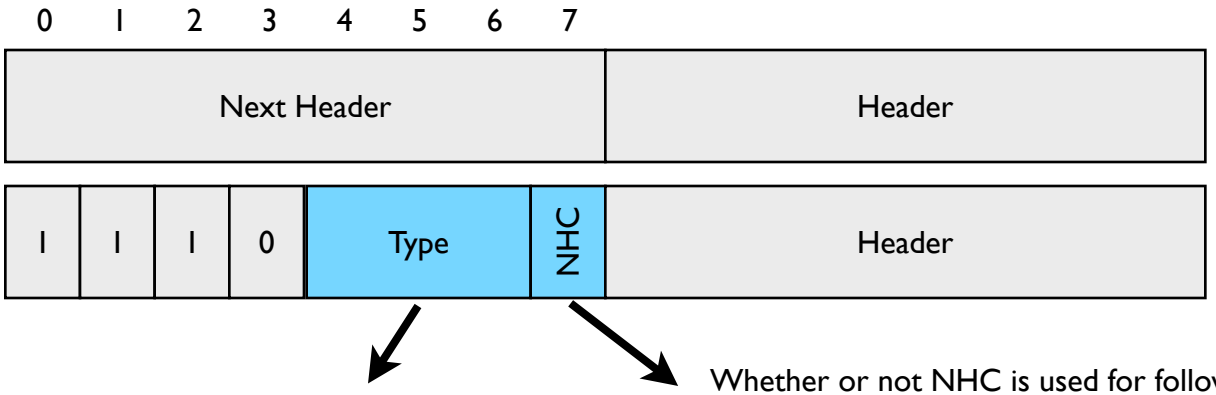
Background

- Improved header compression for:
  - Global Addresses
  - Multicast Addresses
  - Traffic Class and Flow Label
  - Hop Limit
  - UDP Header
  - Arbitrary Next Headers
- Maintain properties of RFC4944 compression
  - Stateless compression for link-local addresses
  - Context-based compression for global addresses

Changes from draft-04

- IP Header Compression
  - Specify default context as CID=0 (ticket #32)
  - Clarify prefix-based multicast encoding format (ticket #33)
  - Specify prefix is link-local prefix for stateless mode (ticket #34)
  - Full 128-bit address only in stateless mode
  - Removed support for compressing unspecified address
  - Allow using inline bits as an index to identify compressed address
- Next Header Encoding
  - Add IPv6 Extension Headers
  - Add IPv6 Header (for IP-in-IP)

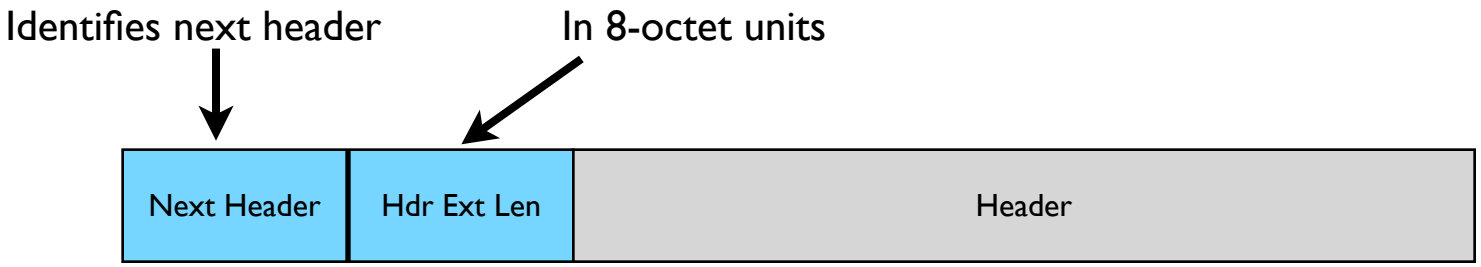
Next Header Encoding



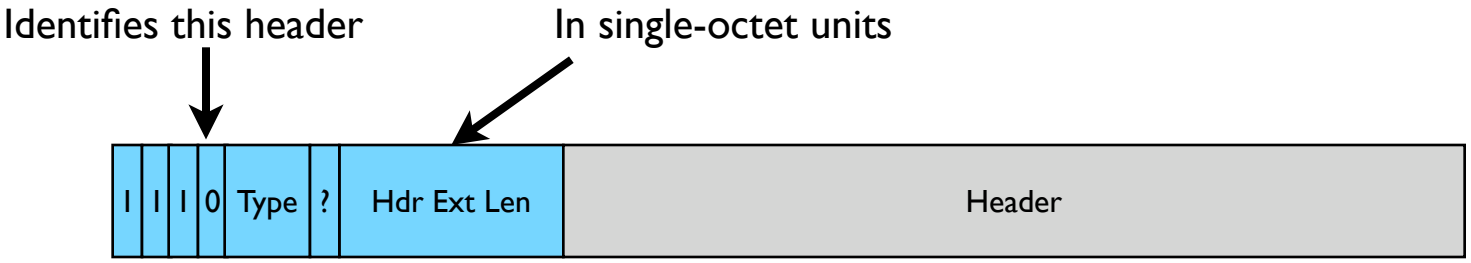
0	Hop-by-Hop Options	RFC2460
1	Routing	RFC2460
2	Fragment	RFC2460
3	Destination Options	RFC2460
4	Mobility Header	RFC3775
5	Reserved	
6	Reserved	
7	IPv6 Header	RFC2460

Next Header Encoding

Standard IPv6 encoding



NHC encoding



Next Steps

- Trivial changes for draft-06
  - Ticket #45: IPHC encoding "utilizes 11 bits" → "utilizes 13 bits"
  - Specify which parts of RFC 4944 is being updated
  - Specify M=0 only for unicast, M=1 only for multicast
  - Ticket #31: IPHC conflicts with ESC dispatch (TF=11, NH=1, HLIM=11)
    - 1) Do not allow this combination or
    - 2) Deprecate/consume/reassign ESC value
- Move to LC soon?

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draft-ietf-6lowpan-nd-04

Authors:
Zach Shelby (ed.)
Jonathan Hui
Pascal Thubert
Samita Chakrabarti
Erik Nordmark
(Carsten Bormann)

Outline

- What is ND for 6LoWPAN (in 1 slide)
- Current status
- Changes since IETF-74 (-02 to -04)
- Open issues on the table
- Next steps

Didn't read the draft yet?

See the end of this slide-set for reference slides

6LoWPAN Neighbor Discovery

- Simple bootstrapping on a LoWPAN
- Multihop router and context information dissemination
- Simplified ND
  - No address resolution, no NS/NA, reduced multicast
- Enabling DAD over entire LoWPANs
  - Wireless non-transitive links, LoWPAN subnet model
- Compatible with link-layer mesh and IP routing
- Support for simple, extended and ad-hoc LoWPANs
- Fault tolerance and duplicate identifier detection

Current status

- Draft was accepted as a WG doc in IETF-73
  - Combination of 5 drafts
  - Lots of good and constructive feedback received
- 2 new revisions since IETF-74
  - Closed 26 tickets so far
- Current status:
  - 4 technical issues currently on the table
  - Fine tuning and minor editing needed
  - We've seen good implementation activity

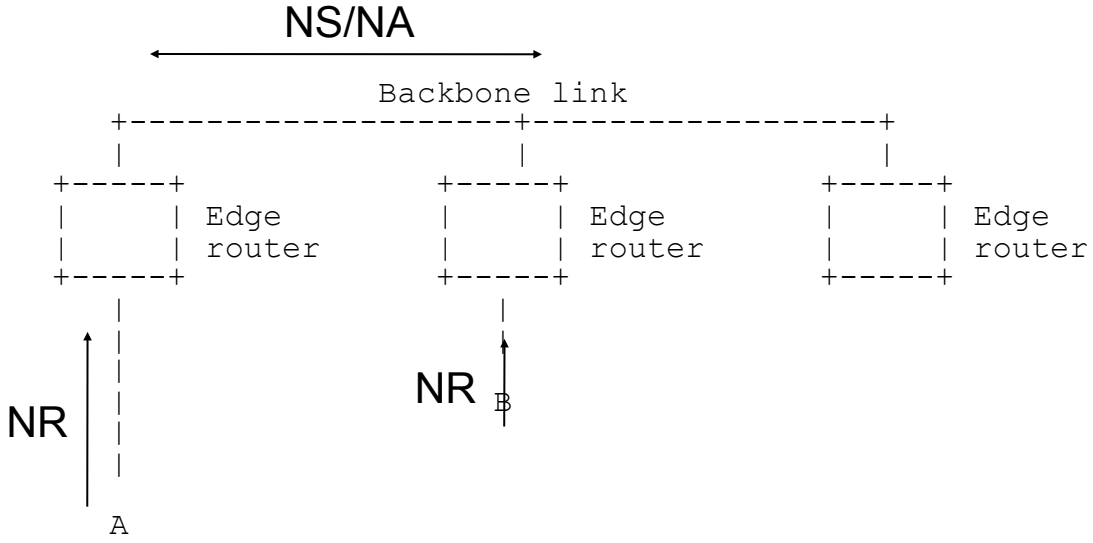
Changes from -02 to -03

- Updated terminology, with RFC4861 non-transitive link
- Protocol overview explains RFC4861 diff in detail
- RR/RC is now Node Registration/Confirmation
- ER Metric now included in 6LoWPAN Prefix Summary option for use in default router determination by hosts
- Whiteboard is supported by all Edge Routers for option simplicity
- NS/NA now completely optional for nodes. No address resolution or NS/NA NUD required
- Link-local operation now compatible with oDAD (was broken)
- Exception to hop limit = 255 for NR/NC messages
- ICMPv6 destination unreachable supported

Changes from -03 to -04

- Moved Ad-hoc LoWPAN operation to Section 7 and made ULA prefix generation a features useful also in Simple and Extended LoWPANs
- Added a 32-bit Owner Nonce to the NR/NC messages and the Whiteboard, removed the TID history
- Improved the duplicate OII detection algorithm using the Owner Nonce
- Clarified the use of Source and Target link-layer options in NR/NC
- Included text on the use of alternative methods to aquired addresses
- Removed S=2 from Address Option (not needed)
- Added a section on router dissemination consistency

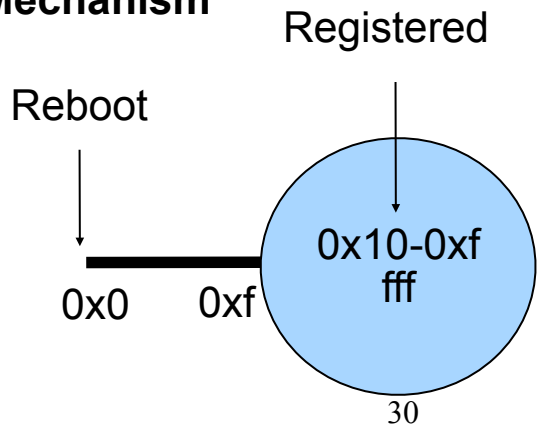
Duplicate identifier detection (new)



NR message contents:

- Owner Interface Identifier (64-bit)
- Nonce (32-bit) **NEW**
- Transaction ID (16-bit)
- Addresses to register

TID Lollypop Mechanism

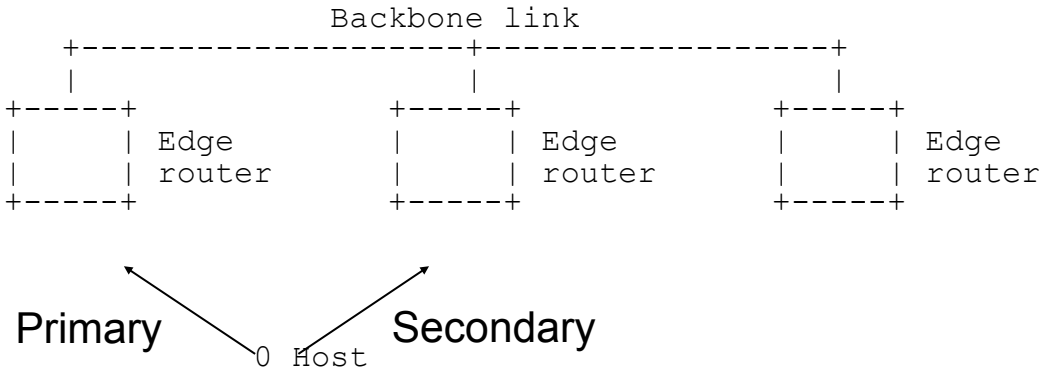


NR message processing

Type	OII	Nonce	TID	Addres	Action
Initial Registration	Unique	*	*	Unique	Accept
New Address or Movement	Duplicate	Same	>	*	Accept
Duplicate message	Duplicate	Same	<=	*	Ignore
Duplicate message	Duplicate	Same	<=	*	Ignore
Node Reboot	Duplicate	Different	< 0x10	*	Accept
OII Collision	Duplicate	Different	> 0xf	*	Reject

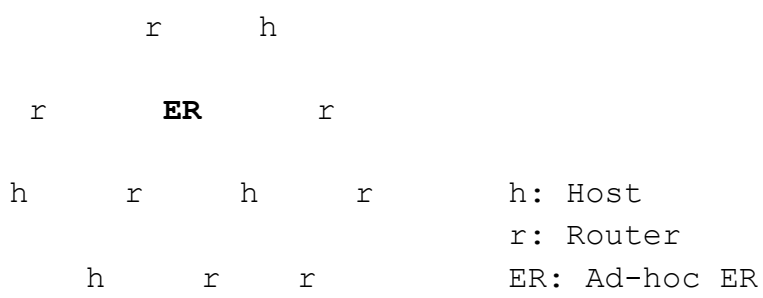
* = Wildcard

Fault tolerance



- Edge Router recovery
- Use of secondary registrations for fault tolerance
  - Prepare network state for movement to new primary
  - Automatic primary->secondary backup operation
  - Bicasting possible

Ad-hoc LoWPANs



- Ad-hoc use of ND for 6lowpan defined
  - Configuration of simplified ER role for a router
  - 100% transparent to LoWPAN nodes
  - ER generates ULA [RFC4193] and disseminates it
  - Whiteboard state can be optimized

Open issues

- Further specification of periods and timeouts
  - NR/NC periods and timeouts
  - RA periods and values
- Optimization of Whiteboard state
  - TID can be reduced to 8 bits
  - Lifetime can be reduced to 16 bits
    - e.g. 10 s units = 10 seconds to a week
- Unspecified address in NR a problem for HC
- Proposal to remove the 6LoWPAN Prefix Information Option (thus CID dissemination defined elsewhere)

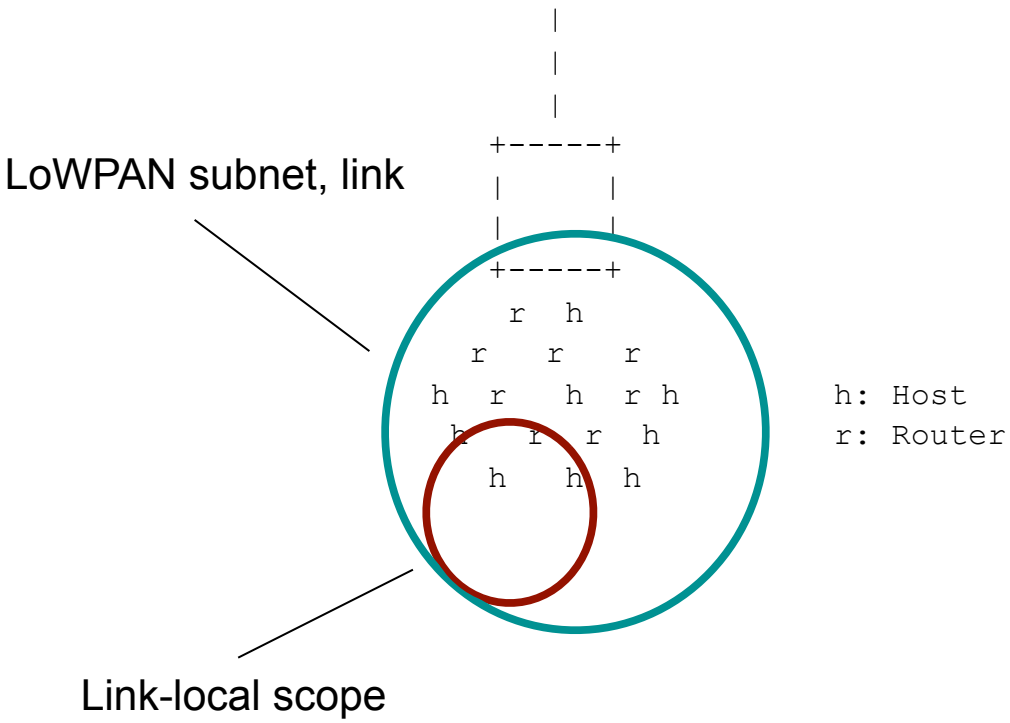
Next steps

- Solve current technical & editorial issues
- Release of -05 within 3 weeks
- Round of comments from ADs and IAB (Dave Thaler)
- Ready for last call after that

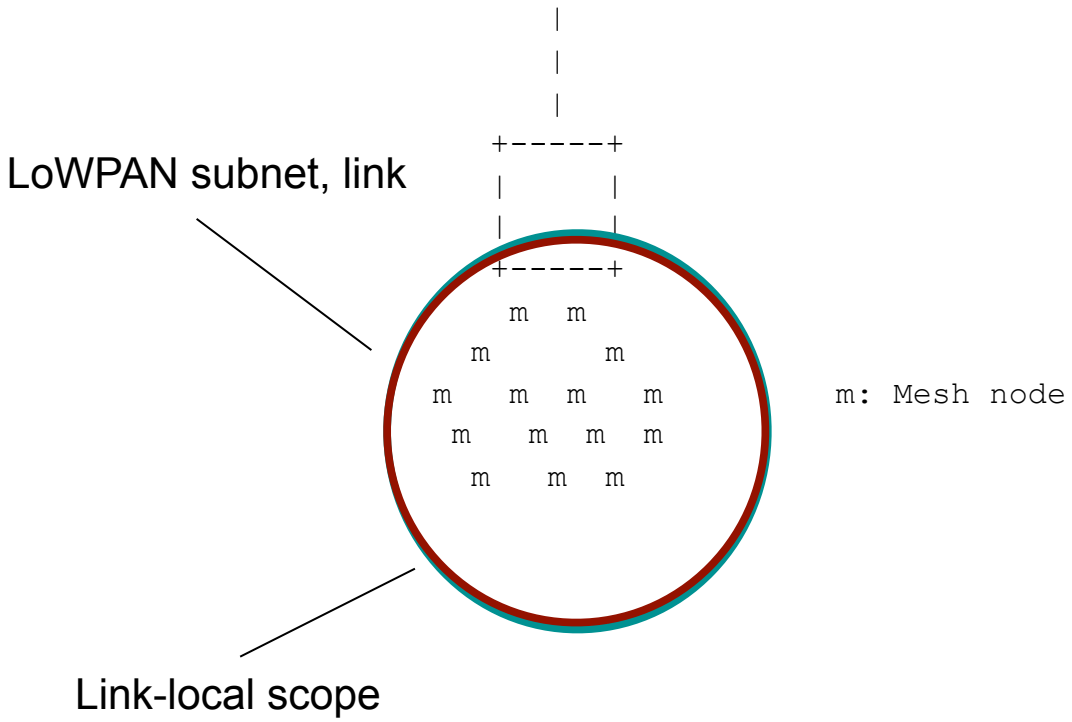
Reference slides

draft-ietf-6lowpan-nd-04

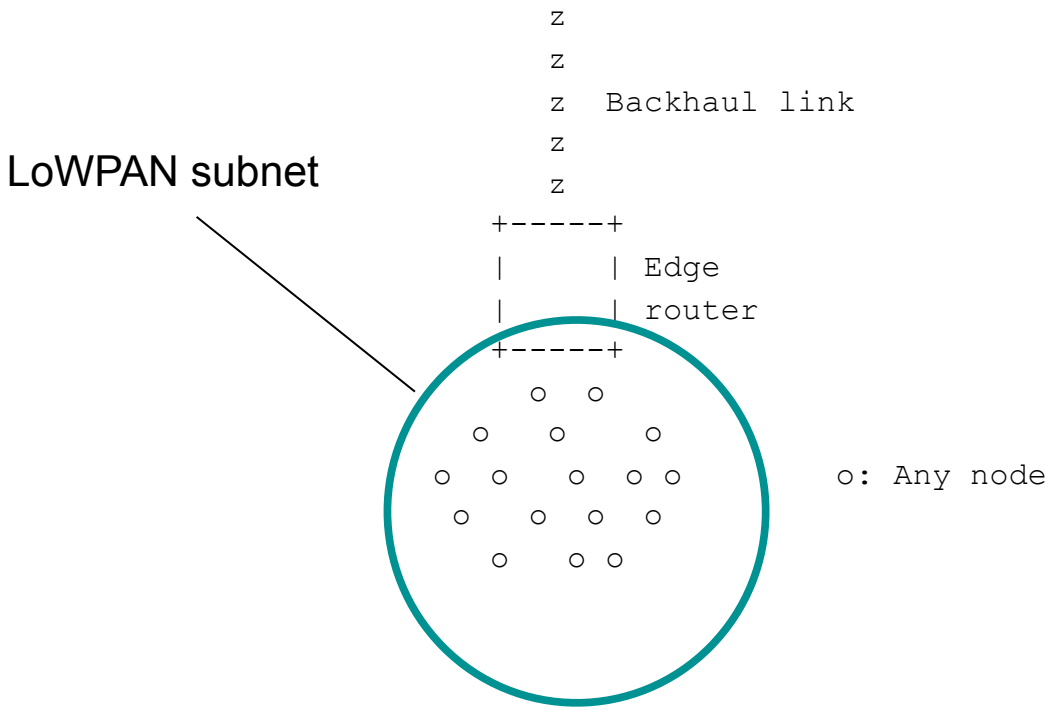
Architecture - Route Over



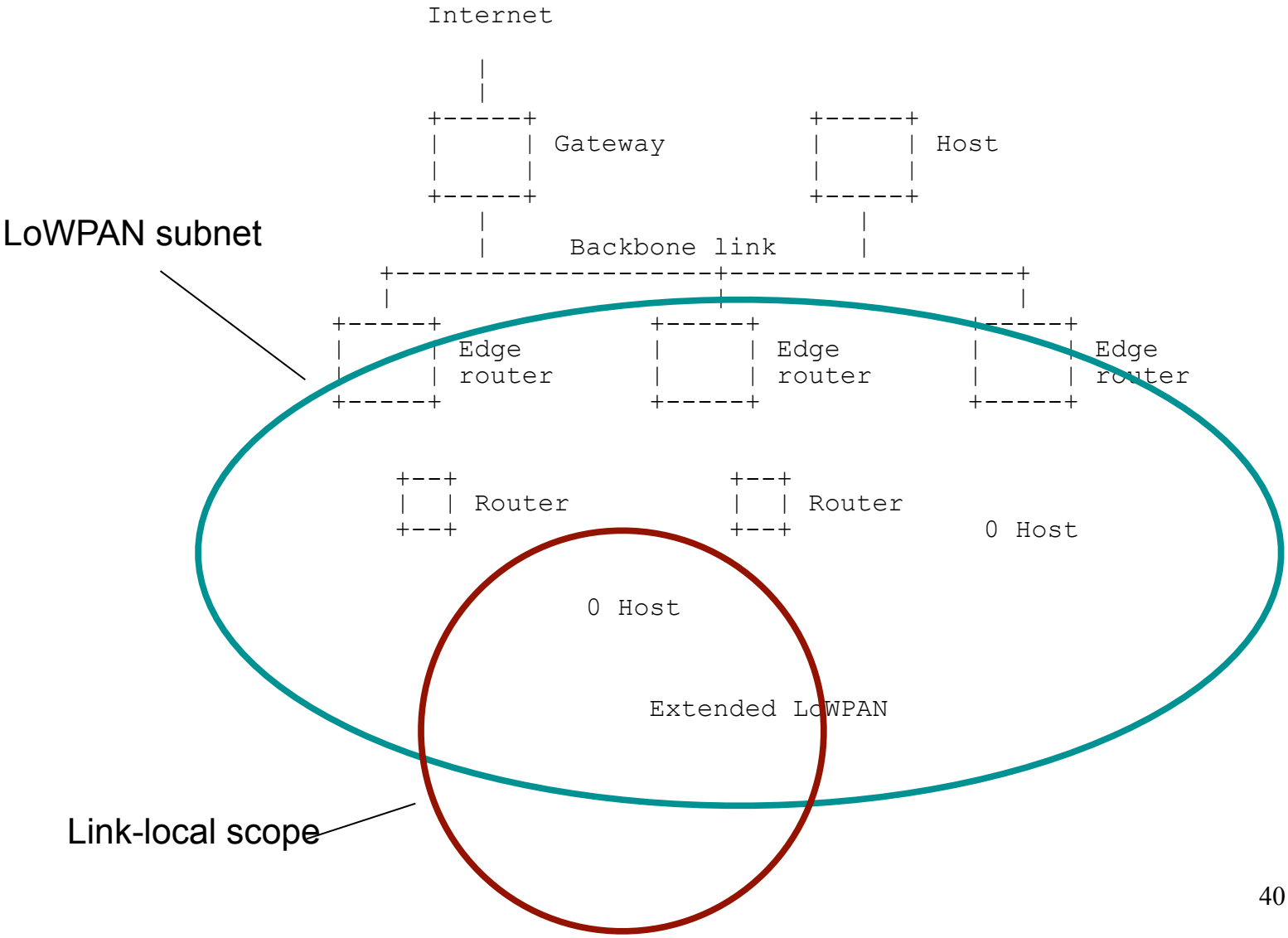
Architecture - Mesh-under



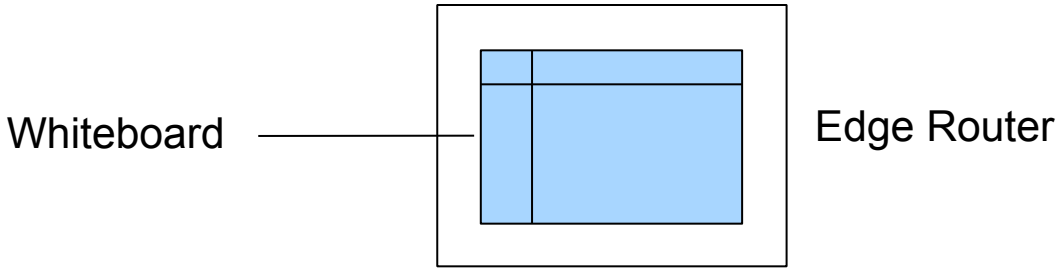
Architecture – Single LoWPAN



Architecture – Extended LoWPAN

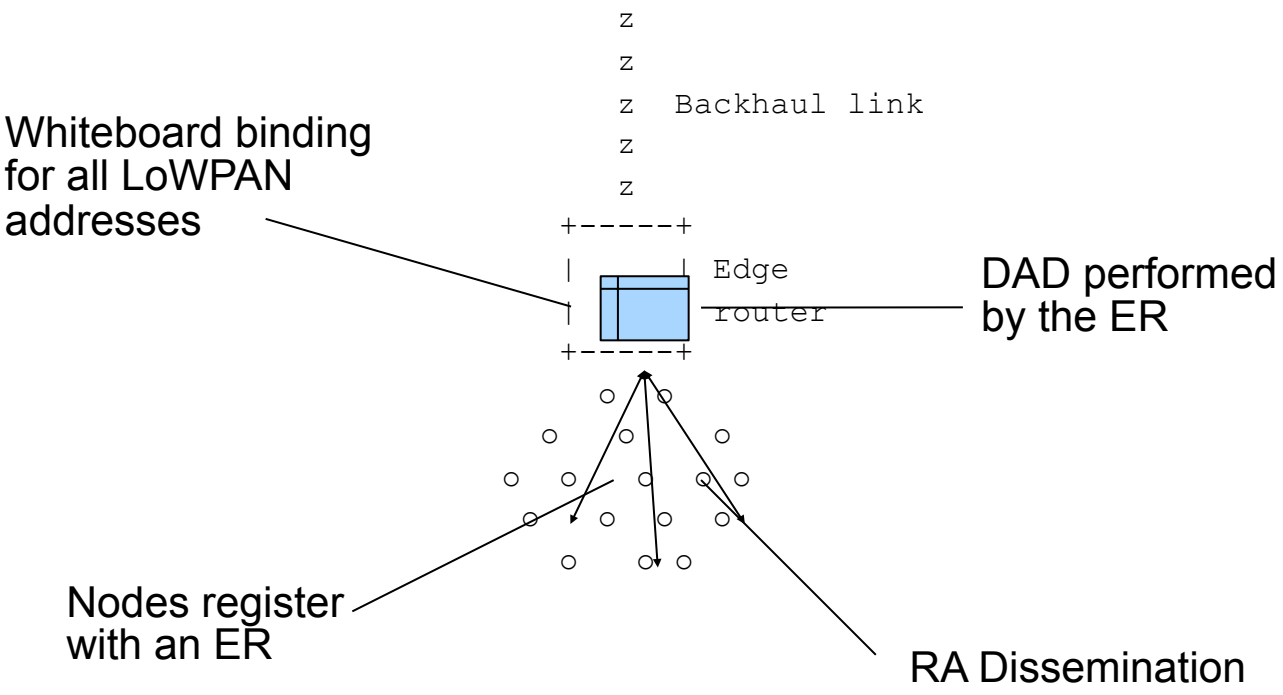


Whiteboard model

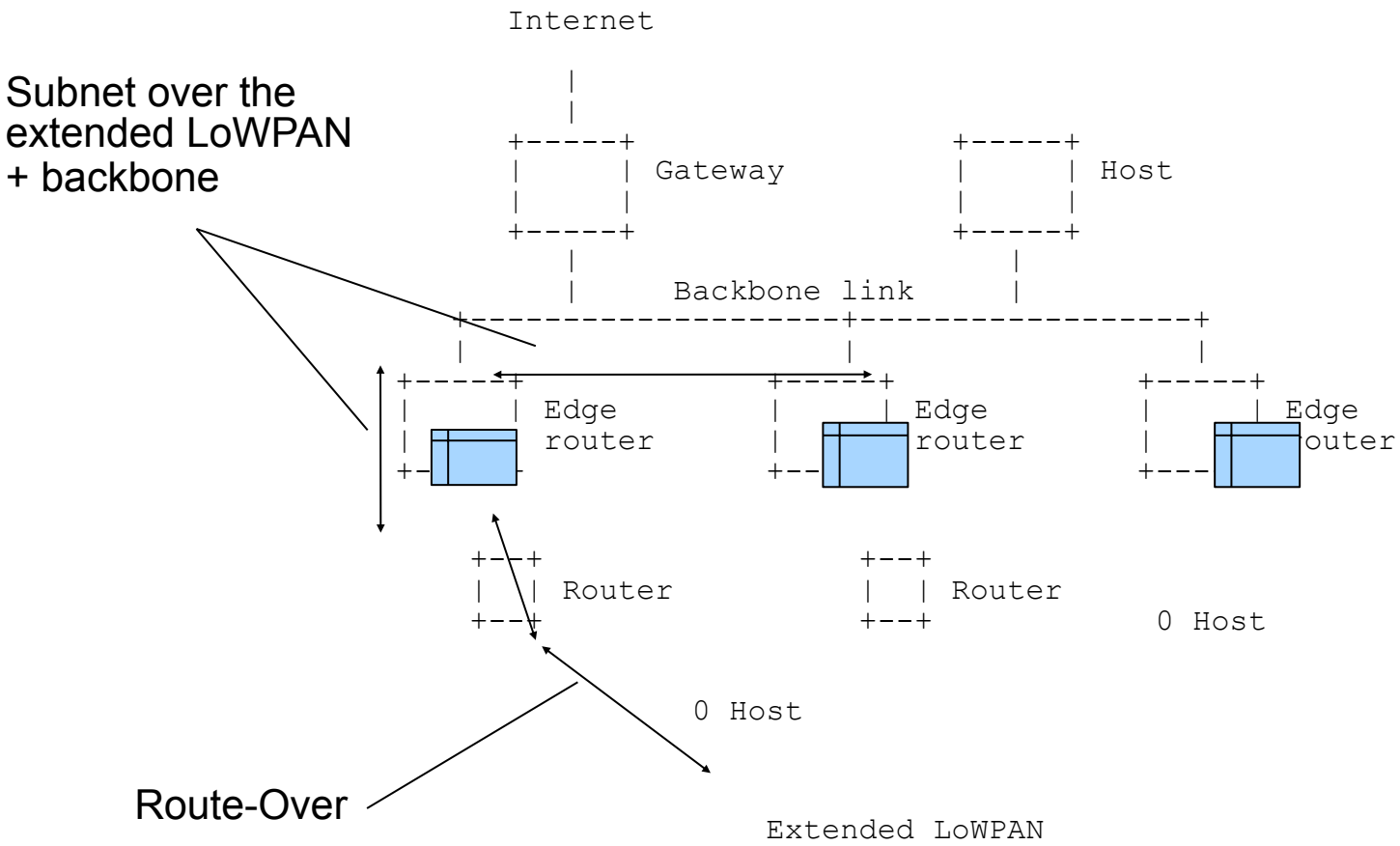


- A whiteboard binding entry has the following fields:
  - `Owner Interface Identifier`
  - `IPv6 Address`
  - `TID, Nonce, Lifetime`
- Bindings are soft
  - Must be refreshed
  - Can be moved between ERs

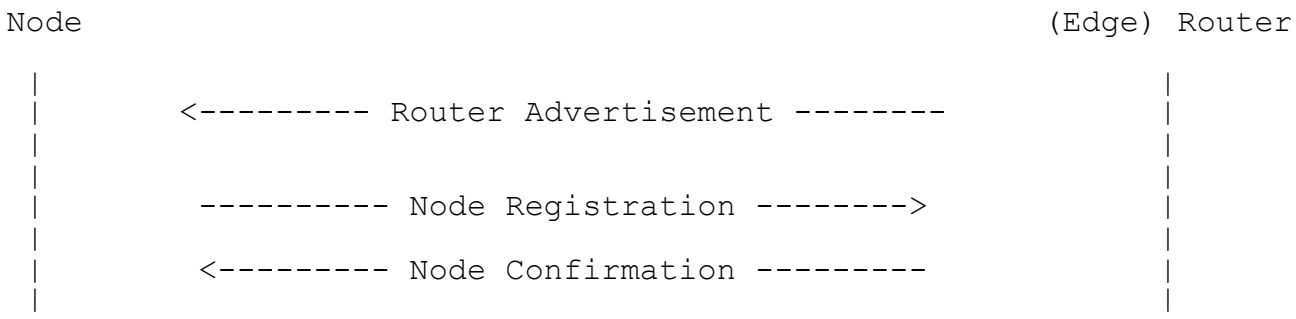
Basic features

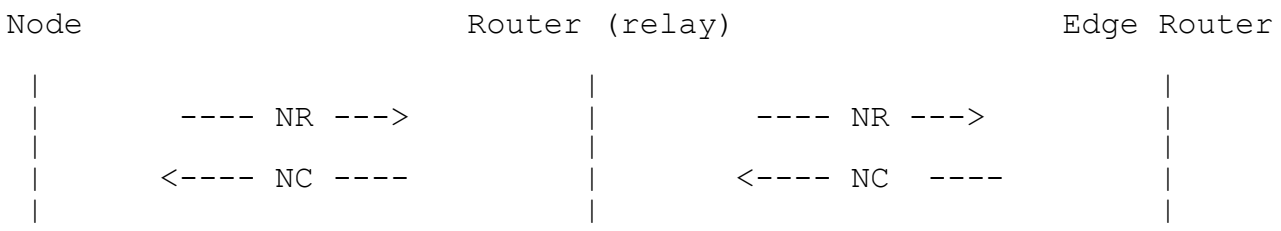


Optional features

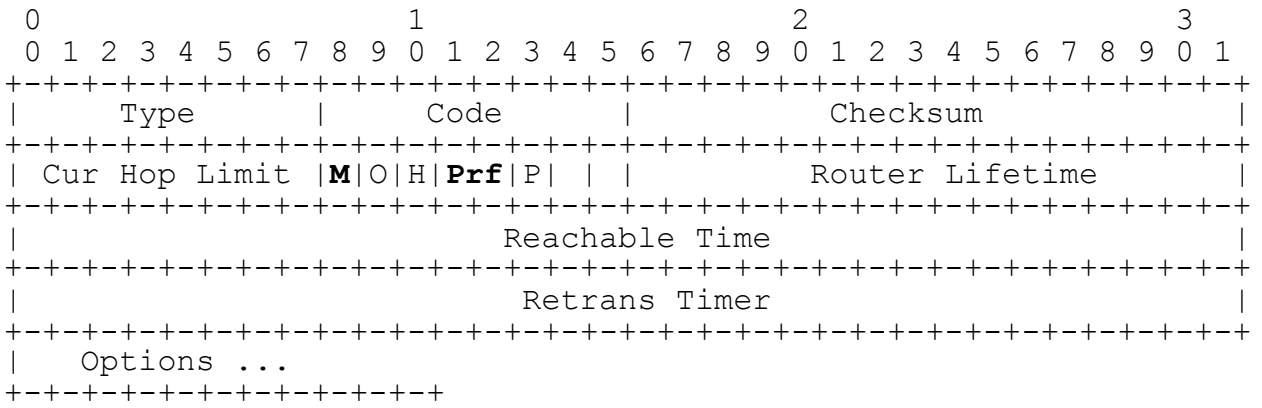


Message exchanges





RA message

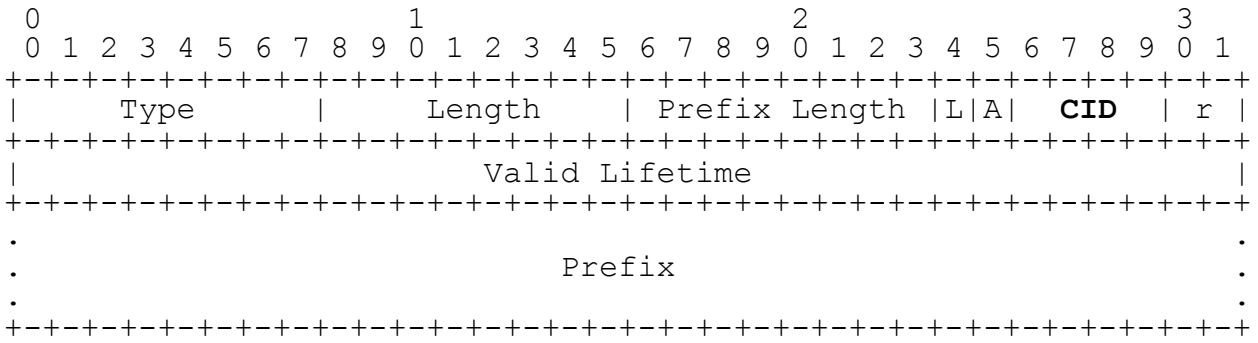


M – Used to indicate that an Edge Router is available.

Prf – Used to indicate if the sender is an Edge Router (Prf=01) or a Router (Prf=00).

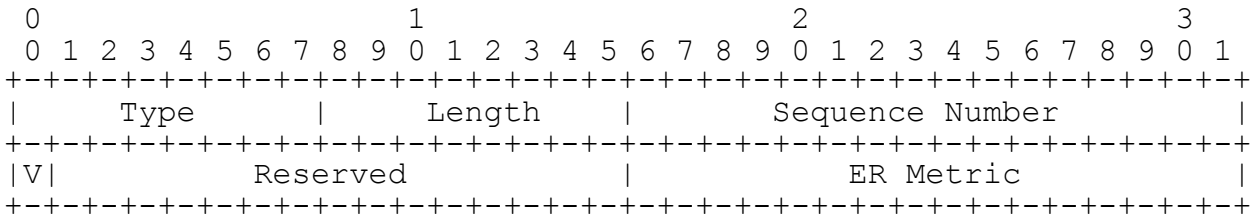
RA options

6LoWPAN Prefix Information Option (A new option!)

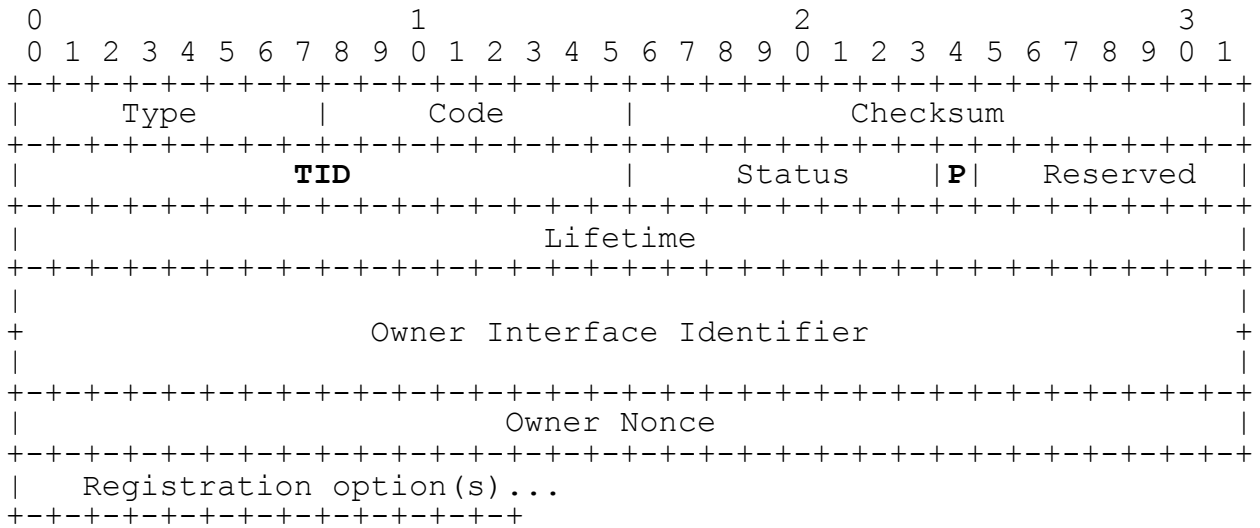


CID – Context Identifier for use in 6LoWPAN HC compression.

Multihop Information Option



NR/NC message

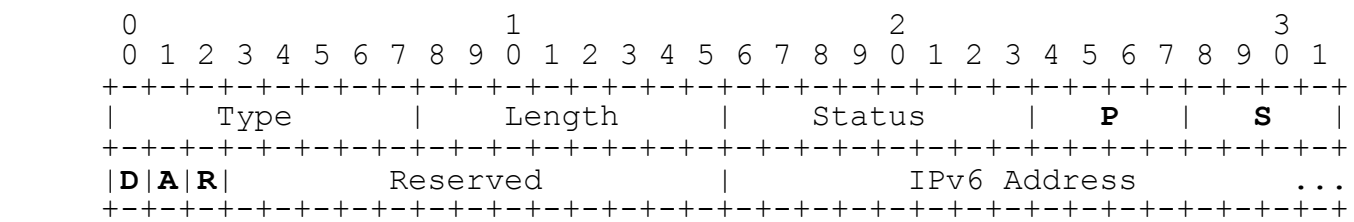


TID – Transaction ID for matching confirmations.

P – Primary flag for using an ER as primary. For use with secondary registrations.

NR/NC options

Address Option



P/S – Prefix and suffix compression fields.

D – Allow duplicates flag.

A – Address request flag.

R – Remove address flag.

Source link-layer address option [RFC4861, RFC4944]

Target link-layer address option [RFC4861, RFC4944]

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11:15	6LowApp Pointer, Rechartering, Lunch		

Design and Application Spaces for 6LoWPAN

(draft-ietf-6lowpan-usecase-03)

IETF-75 Stockholm

Tuesday, July 28, 2009

Eunsook Kim, Dominik Kaspar, Nicolas Chevrollier, JP Vasseur

Draft Status and Next Step

- Changes (-02 → -03)
  - Terminology : from ND
  - Industrial monitoring: overall refinement of the text and update the scenarios and 6lowpan applicability
  - Connected home: modification at scenario and addition of 6lowpan applicability
  - Text refinement through the whole document
- Hope to go to LC

Problem Statement and Requirements for 6LoWPAN Routing

(draft-ietf-6lowpan-routing-requirements-02)
(draft-ietf-6lowpan-routing-requirements-03)

IETF-75 Stockholm

Tuesday, July 28, 2009

Eunsook Kim, Dominik Kaspar, Carles Gomez, Carsten Bormann

Draft Status and Next Step

- Changes (01→02→03)
  - Refinement of Abstract/Introduction/Design Space
    - Explicitly stated that the purpose of this document is not to recommend specific solutions, but to provide general, layer-agnostic guidelines
    - Separate General 6lowpan model from routing design space
  - Terminology – from ND
  - Improvement with details and examples through the whole text
  - Fixed calculation error on Reqt09
  - Improvement of security considerations

Info: Charter Text

- Charter text
  - "6LoWPAN Routing Requirements" will describe **6LoWPAN-specific** requirements on routing protocols used in 6LoWPANs, addressing both the "route-over" and "mesh-under" approach.
  - This document will be created and owned by this working group but is expected to be reviewed by the ROLL WG.
- This work was intended to be done at Sep. 2008

75th IETF: 6lowpan WG Agenda

09:00	Introduction	Chairs	(5)
09:05	802.15.4e update	RS	(10)
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6LoWPAN
Simple Fragment Recovery

(draft-thubert-6lowpan-simple-fragment-recovery-06)

Pascal Thubert

6LoWPAN WG Meeting
75th IETF Meeting
Stockholm, Sweden

Need for fragment recovery

- Considering
  - that 6LoWPAN packets can be as large as 2K bytes
  - 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 ~ 25 fragments at the 6LoWPAN shim layer

- This level of fragmentation is much higher than that traditionally experienced over the Internet with IPv4 fragments.
- At the same time, the use of radios increases the probability of transmission loss and Mesh-Under techniques compound that risk over multiple hops.

Severity of the issue

- Consider a fairly reliable 802.15.4 frame delivery rate of 99.9% over a single 802.15.4 hop.
- The expected delivery rate of a 5-fragment datagram would be about 99.5% over a single 802.15.4 hop.
- However, the expected delivery rate would drop to 95.1% over 10 hops, a reasonable network diameter for 6LoWPAN applications.
- The expected delivery rate for a 1280-byte datagram is 98.4% over a single hop and 85.2% over 10 hops.

Fragment Recovery proposal

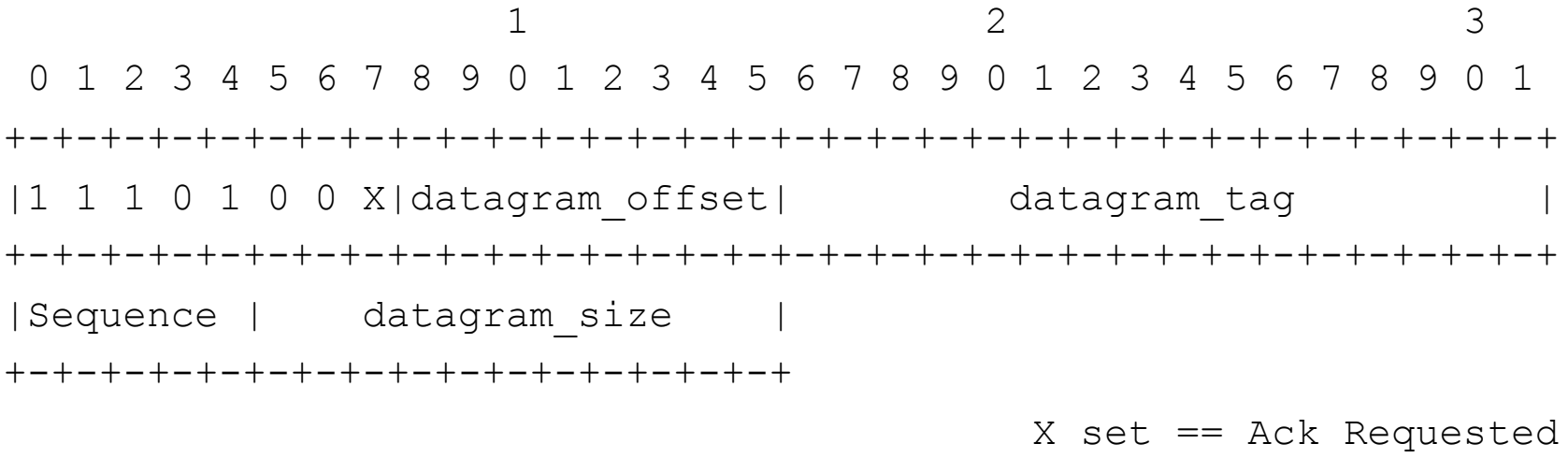
- 32 bits SAck Bitmap
- Variable window size for congestion control
- Round Robin for multipath
- 3 new dispatch types

Pattern	Header Type	
11 101000	RFRAG	- Recoverable Fragment
11 101001	RFRAG-AR	- RFRAG with Ack Request
11 10101x	RFRAG-ACK	- RFRAG Acknowledgement

Changes since IETF 74

- Removed ECN handling
  - WG voted for a separate work
  - Bit is now reserved in FR-Ack
- Compressing ack bitmap
  - Allow piggy backing
- Improved discussion on sizes and risks
- Added text on RFC 4944 deprecation

Recoverable Fragment Dispatch type and Header



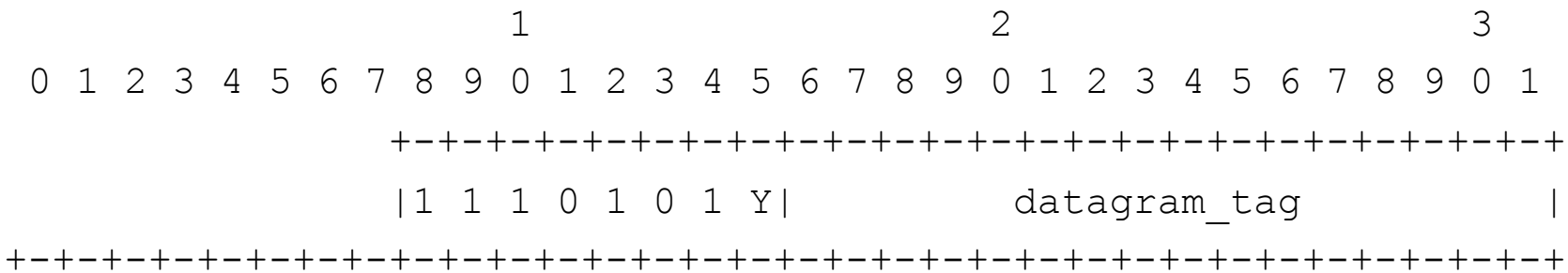
X (check) bit

When set, the sender requires an Acknowledgement from the receiver

Sequence

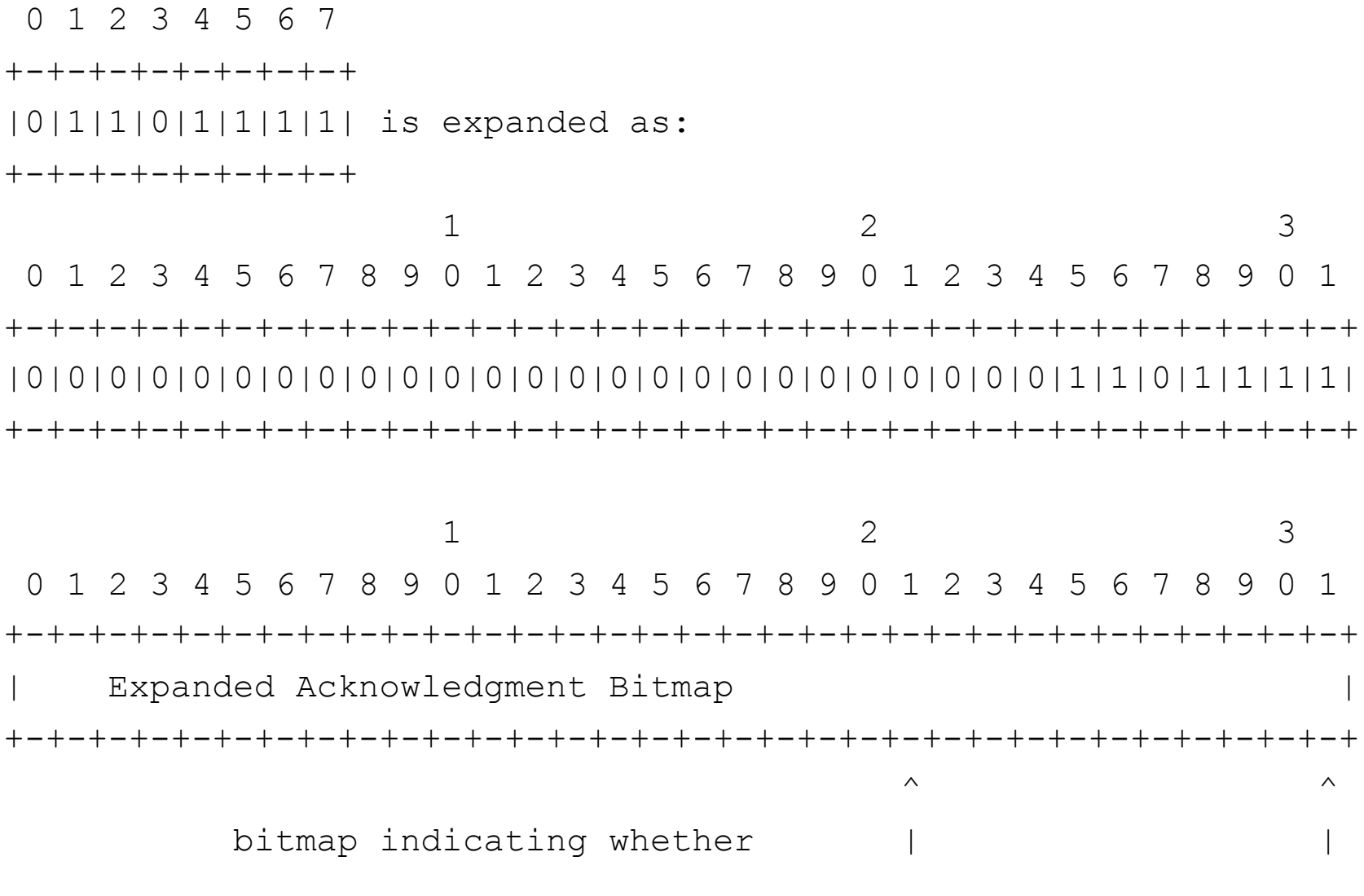
The sequence number of the fragment.
Fragments are numbered [0..N] where N is in [0..31].

Fragment Acknowledgement Dispatch type and Header



Pattern	Size	Ack
0XXXXXXX	1 octet	1 -> 7
10XXXXXX XXXXXXXX	2 octets	1 -> 14
110XXXXX XXXXXXXX XXXXXXXX	3 octets	1 -> 21
1110XXXX XXXXXXXX XXXXXXXX XXXXXXXX	4 octets	1 -> 28

Fragment Acknowledgement Dispatch type and Header (2)



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?

To Be Done Next

- Adopt as a WG Doc?
- RFC 4944 deprecation flow
- ECN handling in a new draft

????? Questions ?????

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SNMP Optimizations for 6LoWPAN

IETF-75 Stockholm

(draft-hamid-6lowpan-snmp-optimizations-01)

Hamid Mukhtar, Juergen Schoenwaelder, Seong-Soon Joo

Claimed benefits of IP Technology for WSNs [RFC 4919]

1. The pervasive nature of IP networks allows use of existing infrastructure.
2. IP-based technologies already exist, are well-known, and proven to be working.
3. An admittedly non-technical but important consideration is that IP networking technology is specified in open and freely available specifications, which is favorable or at least able to be better understood by a wider audience than proprietary solutions.
4. **Tools for diagnostics, management, and commissioning of IP networks already exist.**
5. IP-based devices can be connected readily to other IP-based networks, without the need for intermediate entities like translation gateways or proxies.

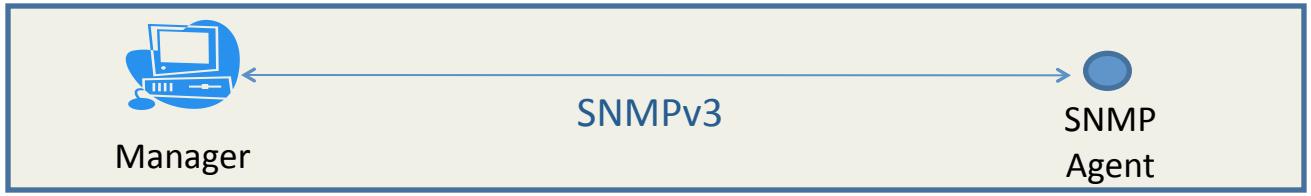
Management Requirements

- RFC 4919
  - Limited overhead
  - Reuse existing protocols.
  - “SNMP functionality may be translated "as is" to LoWPANs with the benefit to utilize existing tools. However, due to the memory, processing, and message size constraints, further investigation is required to determine if the use of SNMPv3 is suitable, or if an appropriate adaptation of SNMPv3 or use of different protocols is in order. “
- One of the goals of 6LoWPAN is to re-use the established IP network management tools
  - Ping, Traceroute, SNMP
  - HP OpenView, IBM Tivoli, Ganglia, Nagios, Cacti etc
  - The underlying IP network enables the use of these tools but the resource constraints of the network need to be taken care of.

SNMP scare

- Pull model
- ASN.1
- Large number of addressable items
- Heavyweight E2E security
- Deployment models for 6LoWPAN?

SNMPv3 Deployment Models



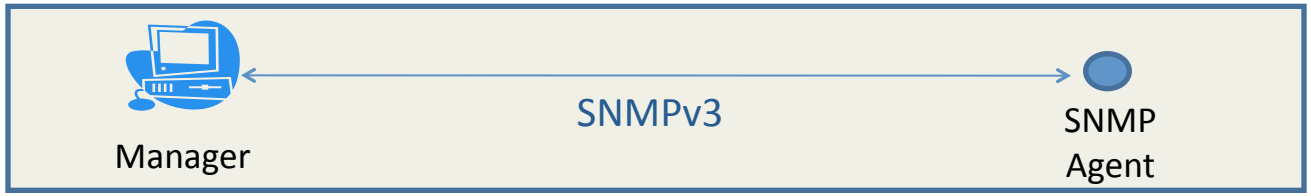
Lightweight End-to-End

Proxy Model

SNMP with Sub-Agent Protocols

SNMP with Data Fusion Protocols

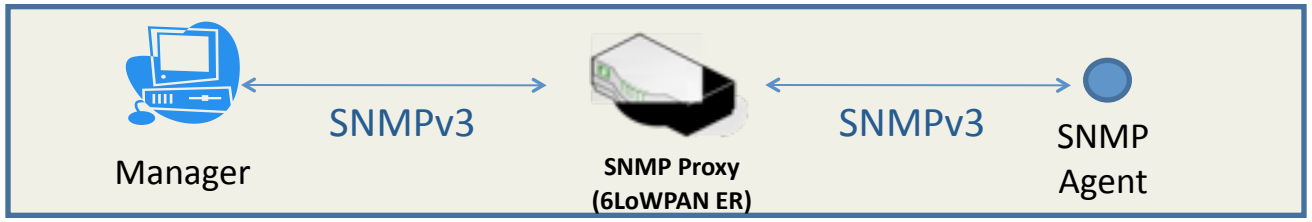
Lightweight End-to-End



+ Direct access to individual nodes
+ Reuse of existing deployed SNMP based tools
o End to End security and Key Management
- 6LowPAN nodes must run an SNMP engine
- Polling nature of SNMP may have high energy costs

- Lightweight SNMP engine design for node's agent
- Support of minimal functionality
- Header/Payload compression?
- Applicability statement for polling guidelines

Proxy Model



+ Indirect access to individual 6LowPAN nodes
+ Alternate transport encoding can reduce message sizes (avoiding the use of BER).
o Reuse of existing SNMP-based tools supporting proxies
o Two security domains, different key management schemes
- 6LowPAN nodes must run an SNMP engine
- Polling nature of SNMP may have high energy costs

- Lightweight SNMP engine design for node's agent
- Further packet encoding needed? HC_SNMP ?
- Applicability statement for polling guidelines

Sub-Agent Protocol

+ Indirect access to individual 6LowPAN nodes
+ BER not used in the subagent protocol
+ Reuse of existing SNMP-based tools supporting contexts
+ Master Agent is MIB ignorant and the subagent is SNMP ignorant
o Two security domains, different key management schemes
o 6LowPAN nodes must run an SNMP subagent
o Limited implementation specific caching may be supported
- Polling nature of SNMP may have high energy costs

- UDP based Agent Sub-Agent communication ?
- Applicability statement for SNMP/Sub-Agent protocol polling

Data Aggregation Protocols

+ Indirect access to individual 6LowPAN nodes
+ Leveraging data fusion protocols
+ SNMP agent acting as a cache, no expensive polling

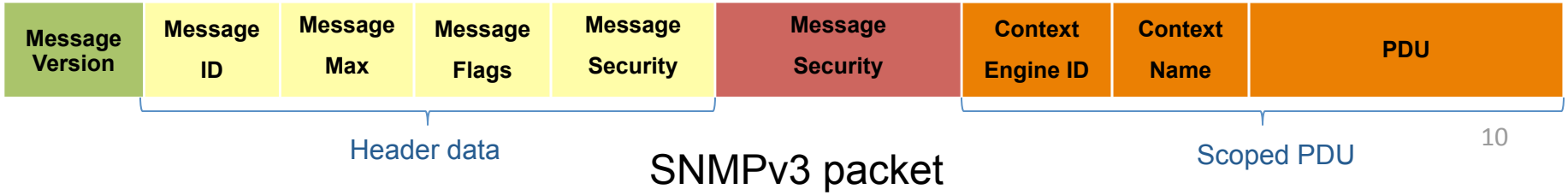
o Reuse of existing SNMP-based tools supporting contexts
o Two security domains, different key management schemes

- No real advantage of 6LoWPAN technology — oops ☺

• Define or reuse an existing data aggregation protocol. (6LoWPAN ??)
• Security model for management data on the 6LoWPAN side.

Minimum packet sizes

- SNMPv2c/SNMPv1 (historic) 18 octets
- SNMPv3 (with USM Security) 65 octets
  - SNMPv3Message 2 byte
  - msgVersion 3 byte
  - HeaderData 15 byte
  - msgSecurityParameters (USM) 23 byte
  - msgData (ScopedPDU) 22 byte
- SNMPv3 (with TSM Security)
  - msgSecurityParameters (TSM) 0 byte
  - Small message framing overhead for stateReferences



Recommendations

- Applicability statement for the End-to-End SNMPv3.
  - Recommendations on how it can be reused “as is”
- SNMPv3 with Header compression at ER
  - Can cut down the lengths further
  - HC_SNMPv3?
- Do we need a subagent protocol?
  - Redefine AgentX for its use over UDP

Possible optimizations for End-to-End Models

Transmission cost

- Avoiding Fragmentation
  - Header
    - HC_SNMP?
    - Changing Encoding
      - Converting BER's TLV (Type Length Value) Encoding to a simpler one for compression.
  - Payload
    - Change Encoding
    - Compression
      - http://tools.ietf.org/html/draft-irtf-nmrg-snmp-compression-01
      - The agent overhead (for decompression)?
    - OID compression
    - Managed Object Aggregation
      - http://tools.ietf.org/html/rfc4498

Memory Cost Reduction

- Minimize MIB overhead
- Lightweight SNMP Security on the node (in case of LW-E2E and Proxy Model)
- Reassembly of large response packets on 6LoWPAN nodes? (not limited to SNMP only)
- Access control
  - Compact permanent authorization tables on the node?
  - Provided on the ER in case of subagent protocol

Security

- Adapt SNMPv3 Security (for LW-E2E and Proxy)
  - SNMPv3 Security Model (USM)
  - Transport Security Model (TSM)
  - Community based security model of SNMPv1 [SNMP-COMMUNITY-MIB]
  - Reuse 6LoWPAN Security Models?

Manager Considerations

- Polling guidelines
  - Frequency of data retrieval
  - Polling pattern (pull v.s push)
  - Nature of data (static/dynamic)
- Adaptability of timeouts
- EngineID discovery
  - EngineID Predeployed or Generated from IP/MAC addresses?
  - Discovered EngineID cached (guidelines can be given the implementers)

MIB Design

- Which standard MIBs to support and why to support them?
- Definition of new MIBs for 6LoWPAN.
- MIB placement (ER or Node)?
- Special caching
  - Timestamps or version numbers may be included.
  - Standard MIBs augmentation?.

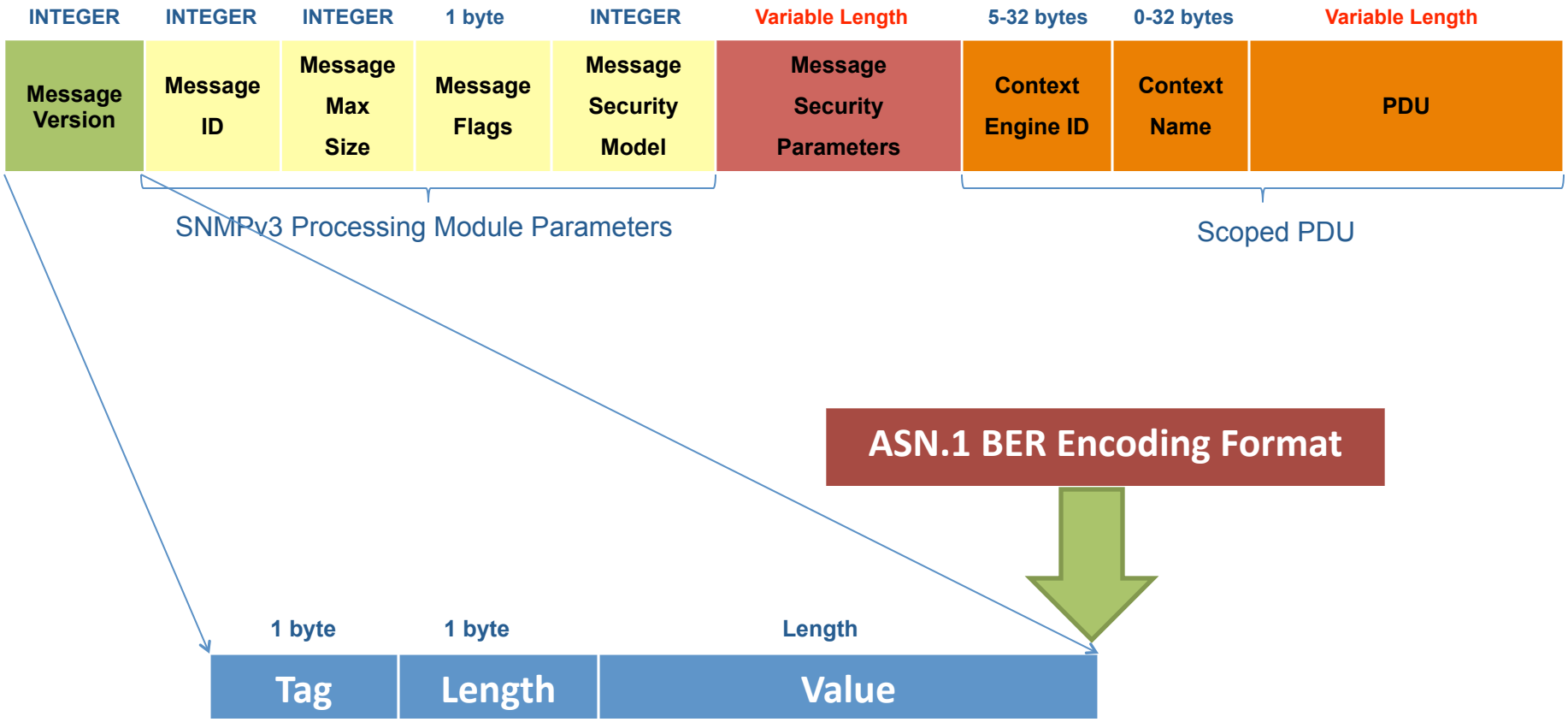
Conclusion

- Reusing existing protocols like SNMP is the advantage that we would get with IP.
- An applicability statement or an simple adaptation of SNMP would enable that.

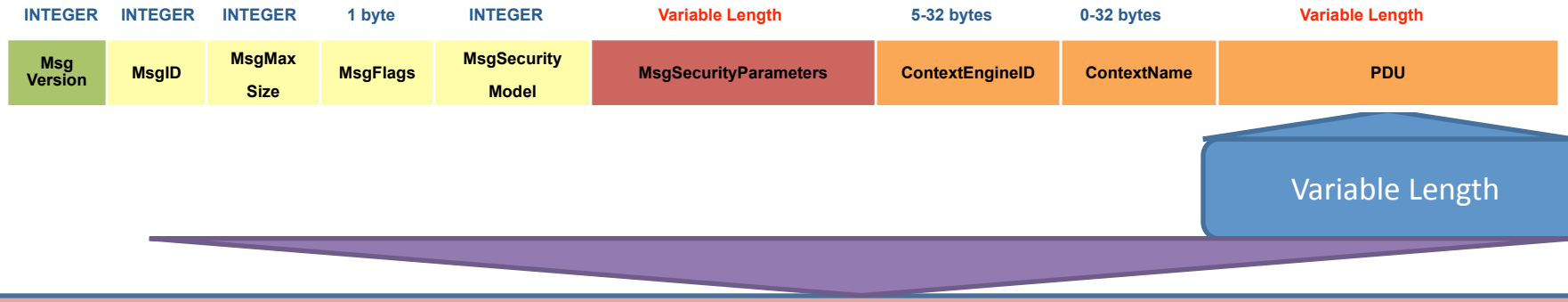
Next step

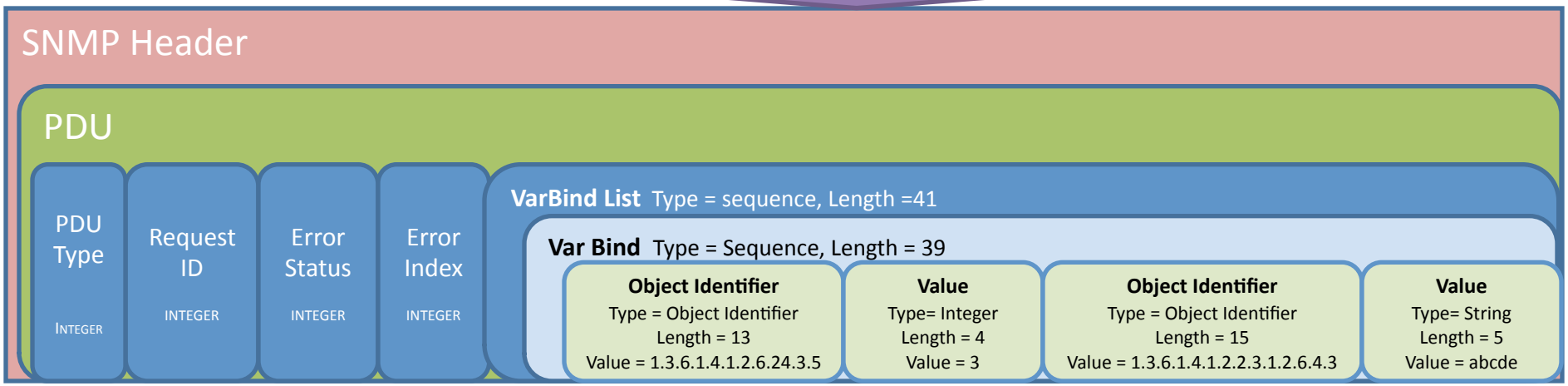
- Comments/suggestions
- Management as a charter Item ?

ASN.1's BER Encoding

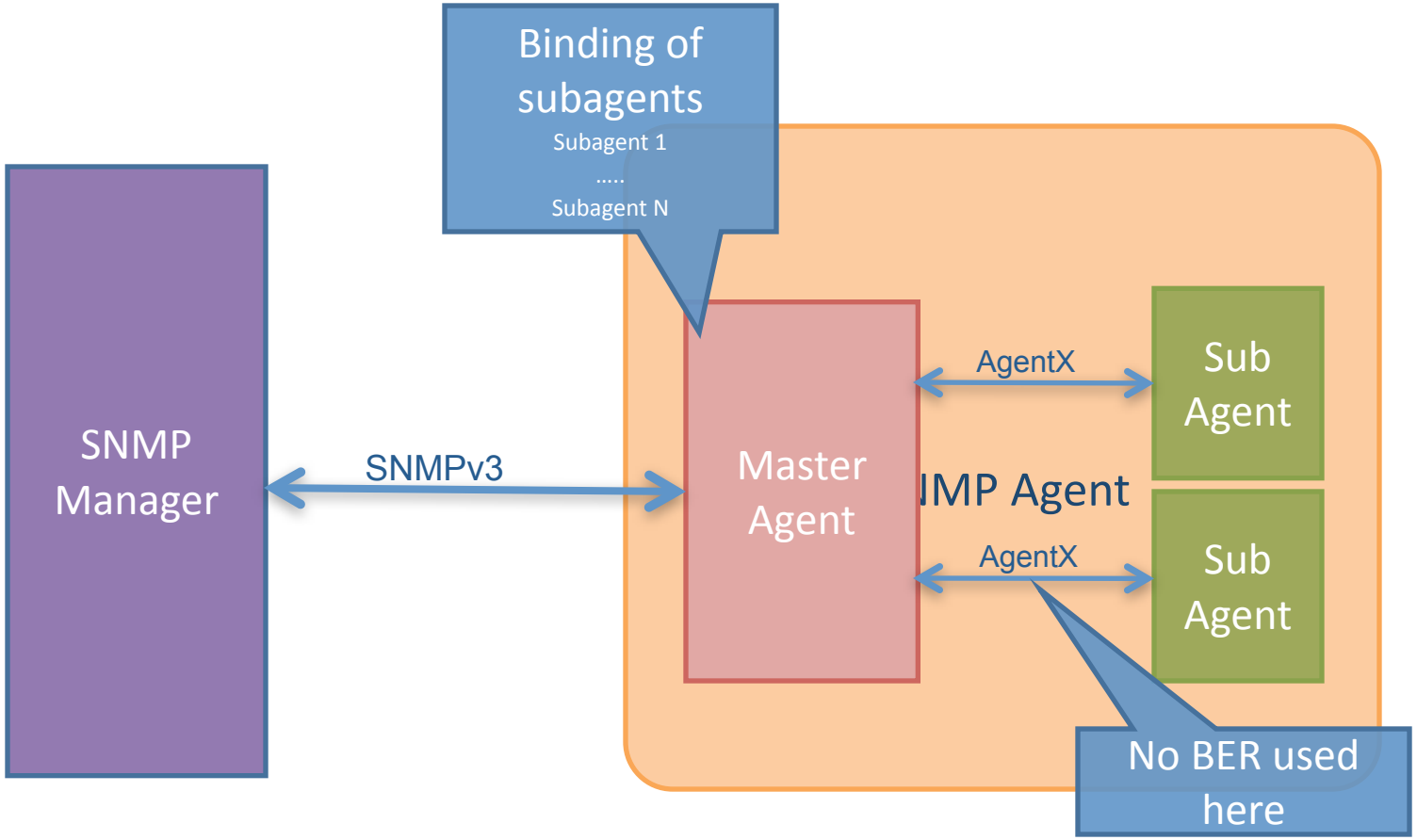


SNMP Packet


INTEGER
INTEGER
INTEGER
1 byte
INTEGER
Variable Length
5-32 bytes
0-32 bytes
Variable Length
Msg Version
MsgID
MsgMax Size
MsgFlags
MsgSecurity Model
MsgSecurityParameters
ContextEngineID
ContextName
PDU
Variable Length


SNMP Header
PDU
PDU Type
INTEGER
Request ID
INTEGER
Error Status
INTEGER
Error Index
INTEGER
VarBind List Type = sequence, Length =41
Var Bind Type = Sequence, Length = 39
Object Identifier
Type = Object Identifier
Length = 13
Value = 1.3.6.1.4.1.2.6.24.3.5
Value
Type= Integer
Length = 4
Value = 3
Object Identifier
Type = Object Identifier
Length = 15
Value = 1.3.6.1.4.1.2.2.3.1.2.6.4.3
Value
Type= String
Length = 5
Value = abcde

SNMP with Sub-Agent Protocols



The master agent is MIB ignorant and SNMP omniscient
The subagent is SNMP ignorant and MIB omniscient

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6LoWPAN Management Information Base (draft-daniel-6lowpan-mib-00.txt)

K. Kim, H. Mukhtar, S. Yoo, S. Daniel Park

6LoWPAN MIB

- Define MIB definitions for 6LoWPAN
  - 6LoWPAN Generic parameters
  - LoWPAN Mesh parameters
  - Route Over parameters
  - 6LoWPAN statistics
  - Relationship and compliance with other MIBs

Generic parameters

- 6lowpanDeviceRole
  - Pan Coordinator, 6LoWPAN Router, 6LoWPAN Mesh Node, 6LoWPAN Node
- 6lowpanDeviceCapabilities
  - Device type, Power source, Security capability, etc
- 6lowpanRoutingProtocol
  - TBD

LoWPAN Mesh parameters

- 6LowpanRoutingTable
- 6LowpanNeighborTable
- 6lowpanUseHierarchicalRouting
- 6lowpanBroadcastSequenceNumber
- 6lowpanAckTimeout

Route-Over parameters

- Edge Router List
- ER-Metrics (only 6LoWPAN Routers)
  - The ER Metric gives an indication of the cost (in routing metric terms) of reaching nodes outside the LoWPAN via an ER through this router.

6LoWPAN statistics

- Number of fragmented packets sent
- Number of reassembled packets sent
- Number of fragmentation errors
- Number of reassembly errors
- TBD

Relationship with other MIBs

- Relationship with IP-MIB
  - IPv6 specific variables
  - Neighbor discovery specific variables
  - TBD
- Other related MIBs
  - ENTITY-SENSOR MIB
  - TBD

Future works

- ER MIB
  - Topology support
    - Simple, Extended, Ad Hoc
  - Whiteboard
    - IPv6 address
    - Owner Interface Identifier
    - Owner Nonce
    - Primary flag
    - Registration Age and Lifetime
  - TBD

Next Steps

- Any comments/suggestions?
- Is the WG interested in this draft as a WG item?

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IP in small nodes

- Constrained nodes:
  - say, 48K, 10K, 8 MHz, Double-AA battery
- IEEE 802.15.4 (≤250 kbit/s, 0.9 or 2.4 GHz)
  - Packet size: < 128 Bytes
- 6LoWPAN (INT)
- ROLL (RTG)
- ???? (APP)

Smart Grid
Industrial
HAN
Urban
...embedded...

6LowApp Bar BOF

- Tue 18:30 Room 202 (“IESG Room”)
- Please read:
  - http://u.nu/6jfh
  - draft-bormann-6lowpan-6lowapp-problem-01.txt
- Beer not included

Rechartering

- Security (cont.)
- Fragment Recovery?
- Commissioning?
- _____
- _____