draft-thubert-6lo-rpl-nhc

Problem with RPL option [RFC6553]

- 8-octets overhead for HbH header in data pkt
  - Almost innocuous with G-PHY (ZigbeeIP, CG-Mesh)
  - May cause fragmentation with classical PHY (127 octets/Frame in 2.4 GHz band)
  - Not compressed by 6LoWPAN HC
  - Wasted Energy in constrained devices
- Additional IP-in-IP encapsulation
  - Deeply aggravating factor for energy consumption and fragmentation
- 6TiSCH supports classical PHY
  - Overheads above are show stoppers for adoption

6lo solution vs. Flow Label

- Flow Label compresses RPI down to 20 bits
- Flow label avoids IP-in-IP encapsulation
- Flow Label needs 6MAN approval
- 6lo/NHC is unambiguous about RPI
- 6lo/NHC allows to compress 2-byte rank
- 6lo/NHC is a compressed form of RFC 6553 as opposed to a new format

draft-thubert-6lo-rpl-nhc

Status

- 02 published
- Priority work due to 6TiSCH dependency

Includes

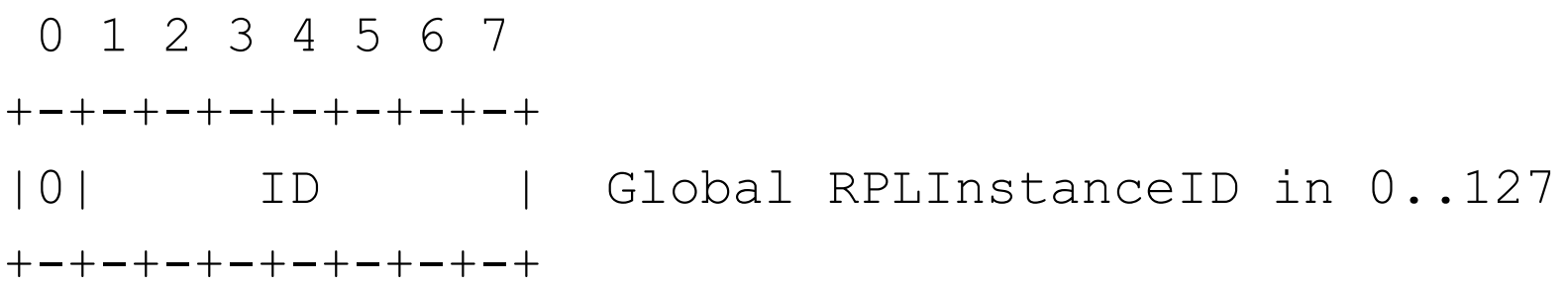
- 6lo next header compression (NHC) for the RPI*
- 3 proposals for the exact format to debate

What's new?

- Converged existing drafts (I-D.bormann-6lo-rpl-mesh)

* Really: a compressed form for an IPV6 HbH header with a RPL Option that transports the RPL Packet Information (RPI)

Compressing the RPLInstanceId



For the global Instance 0, the RPLInstanceID field is all zeroes

Define ‘I’ flag that, when set, signals a global Instance 0, elided.

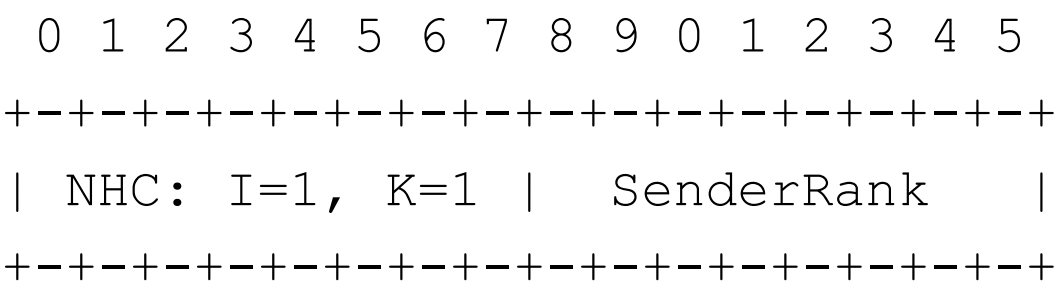
Compressing the SenderRank

```
DAGRank(rank) = floor(rank/MinHopRankIncrease)
```

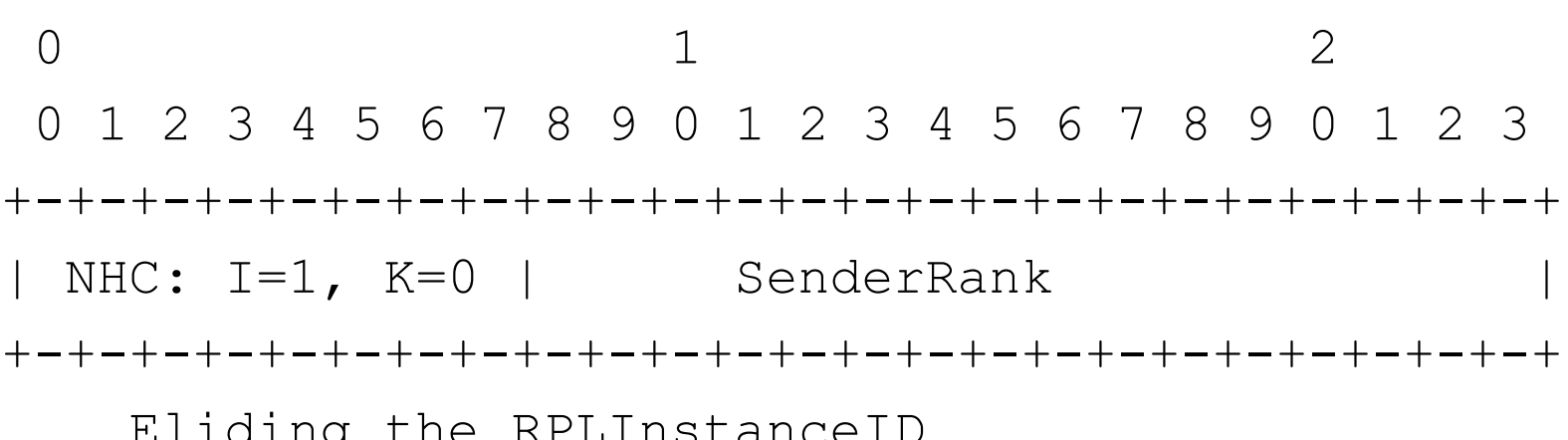
If MinHopRankIncrease is set to a multiple of 256, the least significant 8 bits of the SenderRank will be all zeroes; by eliding those, the SenderRank can be compressed into a single byte.

Define a 'K' flag that, when set, signals that a single byte is used.

Compressing the RPLInstanceId

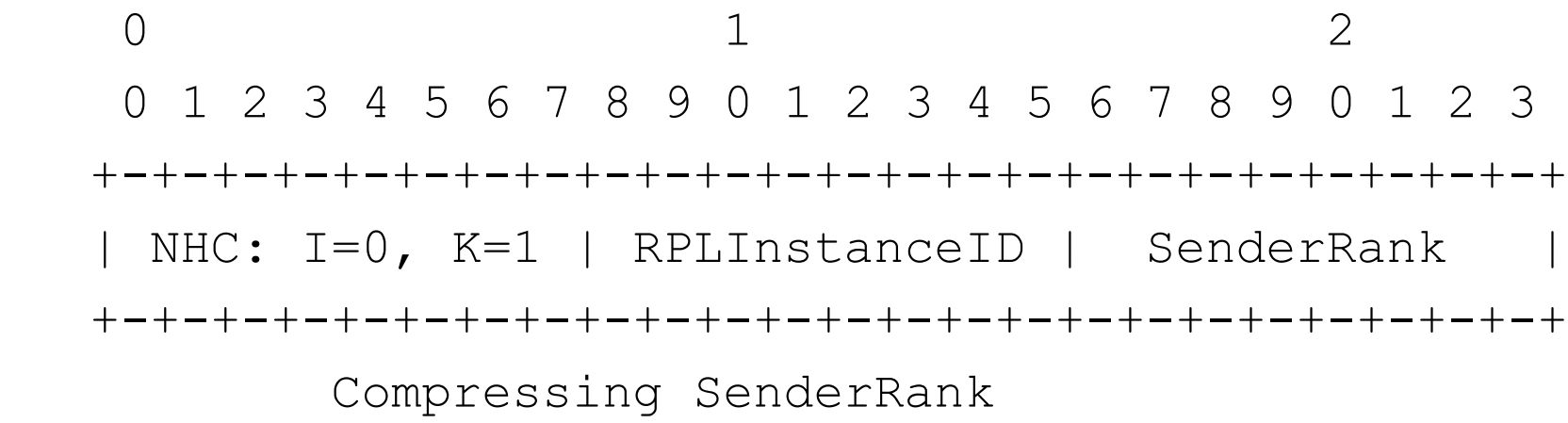


The most compressed RPI_NHC

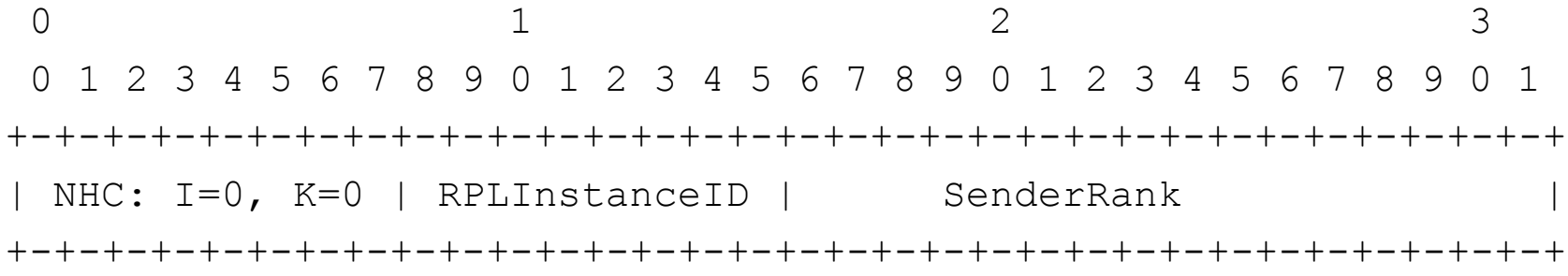


Eliding the RPLInstanceID

Compressing the RPLInstanceId



Compressing SenderRank



Least compressed form of RPI_NHC

Possible NHC encodings

- “Greedy” encoding option
  - Uses NHC 1:0:x:x:x:x:x:x for RPL opt. flags + NH flag
- “Conservative” encoding option
  - Adds to Ext. ID enum. of RFC 6282 LOWPAN_NHC
  - An additional byte for RPI flags (vs. Greedy)
- “Efficient” encoding option
  - Trades Complexity for NHC footprint
  - Compression as good as “Greedy” in normal case
  - Breaks from simple RFC 6282 encoding model
  - Defines new escape mechanism
  - Inserts byte upon forwarding exception

draft-thubert-6lo-rfc6775-update-reqs

Goals

- 6LoWPAN host attachment to L3 (RPL) mesh
- Host mobility within the L3 mesh
- Registration for Proxy ND operations
- Separation of roles 6LBR vs. 6BBR
- Secure registration and address protection

draft-thubert-6lo-rfc6775-update-reqs

Draft Status

- 05 published (time to pass ownership to WG)

Draft Includes

- Requirements from Industrial networks (6TiSCH)
- Requirements from AMI/AMR networks
- 23 requirements total

What's new?

- Simplified content down to 5 pages of pure reqs
- Overview referencing 6TiSCH architecture
- Moved proposed changes to appendix

Requirements Related to Mobility

Req1.1: Upon a change of point of attachment, connectivity via a new 6LR MUST be restored timely without the need to de-register from the previous 6LR.

Req1.2: For that purpose, the protocol MUST enable to differentiate multiple registrations from a same 6LoWPAN Node from two different 6LoWPAN Nodes claiming a same address.

Requirements Related to Mobility

Req1.3: This information MUST be passed from the 6LR to the 6LBR, and the 6LBR SHOULD be able to clean up the stale state asynchronously in the previous 6LR.

Req1.4: A 6LoWPAN Node SHOULD also be capable to register a same Address to multiple 6LRs, and this, concurrently.

Requirements Related to Routing Protocols

Req2.1: The ND registration method SHOULD be extended in such a fashion that the 6LR MAY advertise the Address of a 6LoWPAN Node over RPL and obtain reachability to that Address over the RPL domain.

Req2.3: Depending on their applicability to LLNs, other standard mesh /MANET protocols MAY be considered as well.

Requirements Related to Routing Protocols

• Req2.2: The Address Registration Option that is used in the ND registration SHOULD be extended to carry enough information to generate a DAO message as specified in [RFC6550] section 6.4, in particular the capability to compute a DAOSequence and, as an option, a RPLInstanceID.

Requirements Related to Routing Protocols

• Req2.4: Multicast operations SHOULD be supported and optimized. Groups MAY be formed by device type (e.g. routers, street lamps), location (Geography, RPL sub-tree), or both. RPL already has the capability to advertise multicast groups; whether ND is appropriate for the registration to the 6BBR is to be defined, considering the additional burden of supporting the Multicast Listener Discovery Version 2 [RFC3810] (MLDv2) for IPv6.

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Requirements Related to the Variety of Low-Power Link types

Req3.1: The support of the registration mechanism SHOULD be extended to more LLN links, matching at least the links that are considered by 6lo as well as other popular Low-Power links such as Low-Power Wi-Fi.

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Requirements Related to the Variety of Low-Power Link types

Req3.2: As part of this extension, a mechanism to compute a unique Identifier should be provided, with the capability to form a Link- Local Address that can not be a duplicate. The Identifier SHOULD be unique at least to the domain where an Address formed by this device may be advertised through ND mechanisms.

Requirements Related to the Variety of Low-Power Link types

Req3.3: The Address Registration Option used in the ND registration SHOULD be extended to carry the relevant forms of unique Identifier.

Requirements Related to Proxy Operations

Req4.1: The registration mechanism SHOULD enable a third party to proxy register an Address on behalf of a 6LoWPAN node that may be sleeping or located deeper in an LLN mesh.

Requirements Related to Security

Req5.1: 6LoWPAN ND security mechanisms SHOULD provide a mechanism for the 6LR, 6LBR and 6BBR to authenticate and authorize one another for their respective roles, as well as with the 6LoWPAN Node for the role of 6LR.

Requirements Related to Security

Req5.2: 6LoWPAN ND security mechanisms SHOULD provide a mechanism for the 6LR and the 6LBR to validate whether a new registration corresponds to a same 6LoWPAN Node, and, if not, determine the rightful owner, and deny or clean-up the registration that is deemed in excess.

Requirements Related to Security

Req5.3: 6LoWPAN ND security mechanisms SHOULD lead to small packet sizes. In particular, the NS, NA, DAR and DAC messages for a re-registration flow SHOULD NOT exceed 80 octets so as to fit in a secured IEEE802.15.4 frame.

Requirements Related to Security

Req5.4: Recurrent 6LoWPAN ND security operations MUST NOT be computationally intensive on the LoWPAN Node CPU. When a Key hash calculation is employed, a mechanism lighter than SHA-1 SHOULD be preferred.

Requirements Related to Security

Req5.5: The number of Keys that the 6LoWPAN Node needs to manipulate SHOULD be minimized.

Req5.6: The 6LoWPAN ND security mechanisms SHOULD enable CCM* for use at both Layer 2 and Layer 3, and SHOULD enable the reuse of security code that has to be present on the device for upper layer security such as TLS.

Requirements Related to Security

Req5.7: Public key and signature sizes SHOULD be minimized while maintaining adequate confidentiality and data origin authentication for multiple types of applications with various degrees of criticality.

Requirements Related to Low-Power devices

Req6.1: The registration mechanism SHOULD be applicable to a Low- Power device regardless of the link type, and enable a 6BBR to operate as a proxy to defend the registered Addresses on its behalf.

Requirements Related to Low-Power devices

Req6.2: The registration mechanism SHOULD enable long sleep durations, in the order of multiple days to a month, for devices capable of operating over the course of ten or more years without the need to recharge or replace the batteries.

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Requirements Related to Scalability

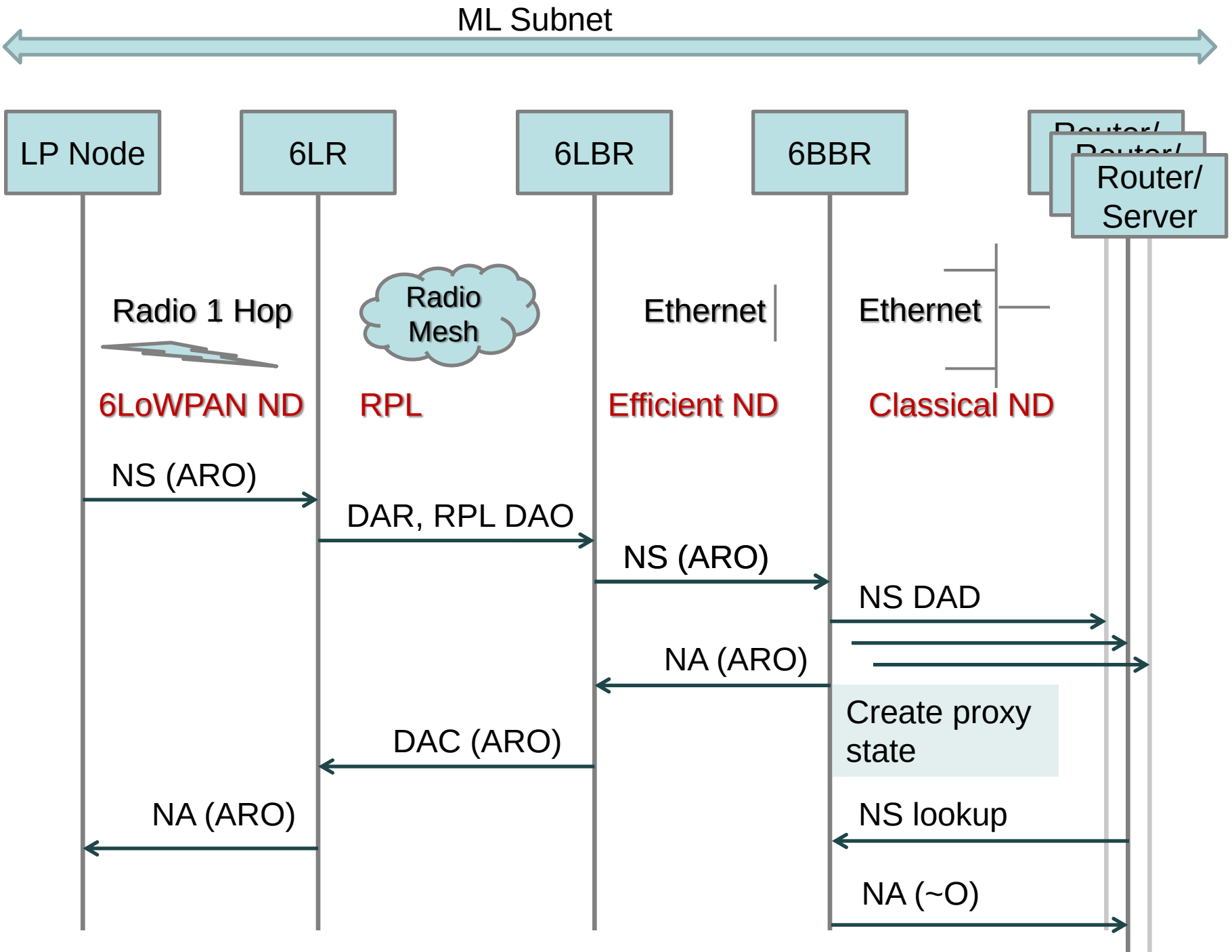
Req7.1: The registration mechanism SHOULD enable a single 6LBR to register multiple thousands of devices.

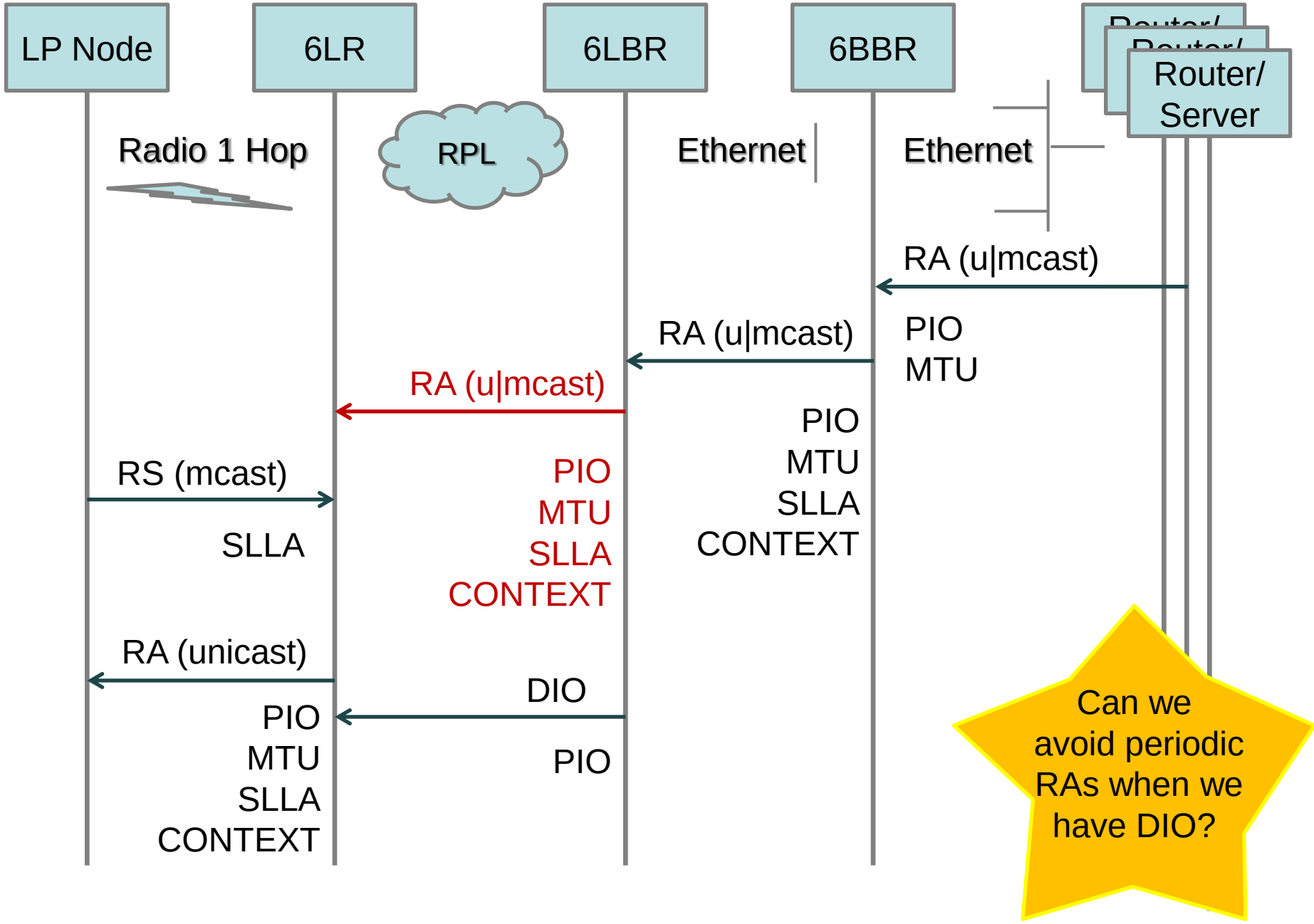
Req7.2: The timing of the registration operation should allow for a large latency such as found in LLNs with ten and more hops.

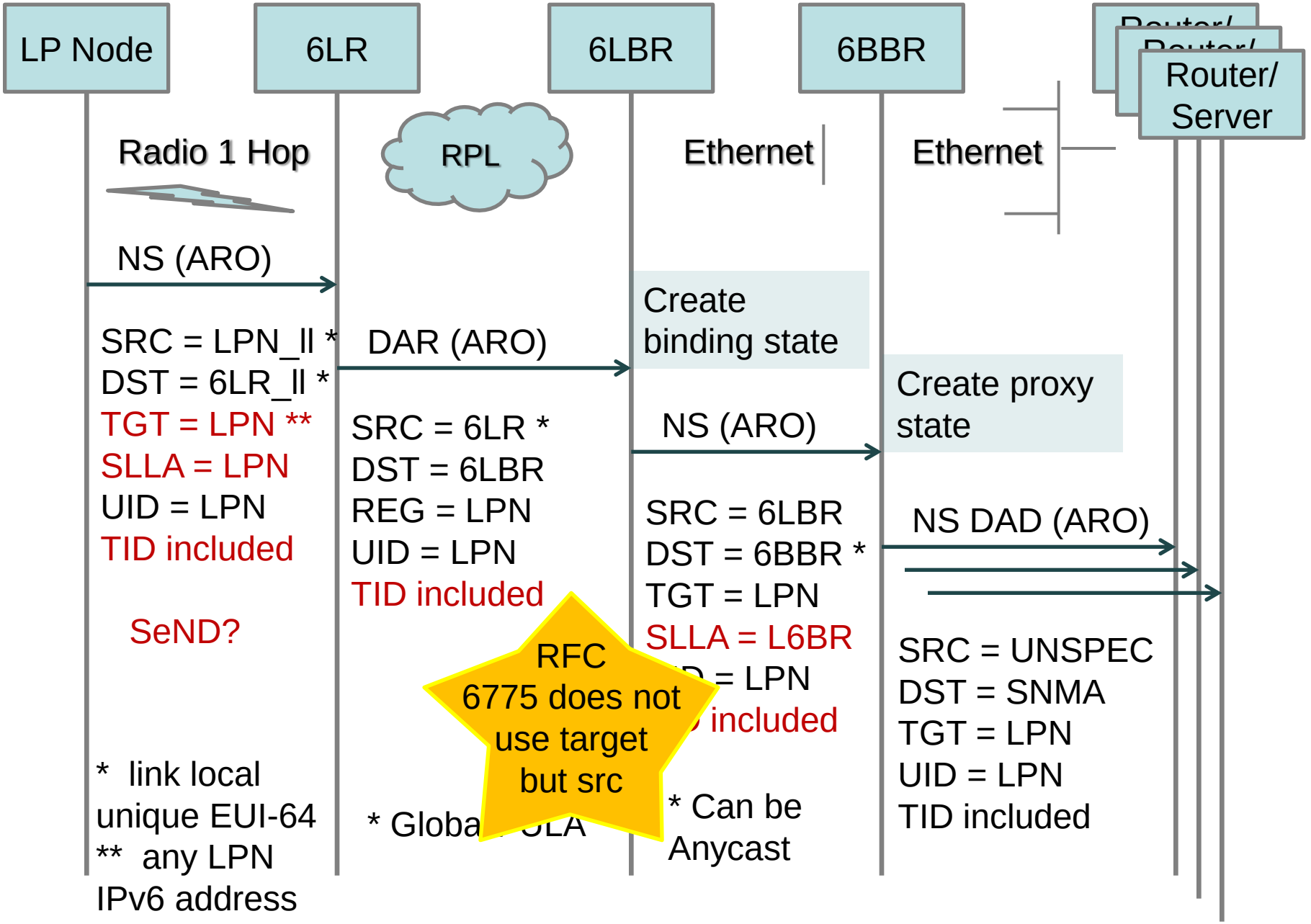
Thank you!

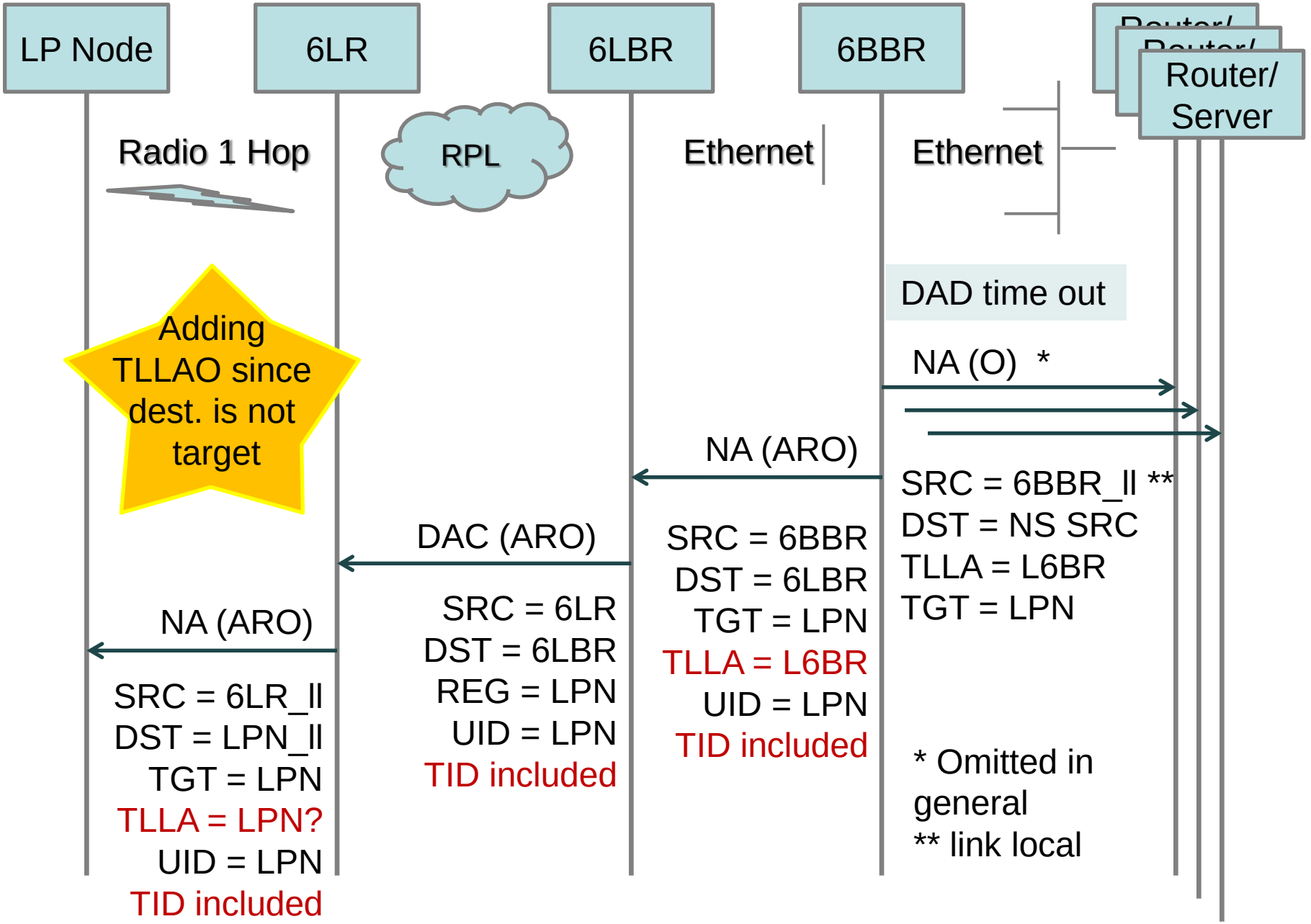
Normal registration

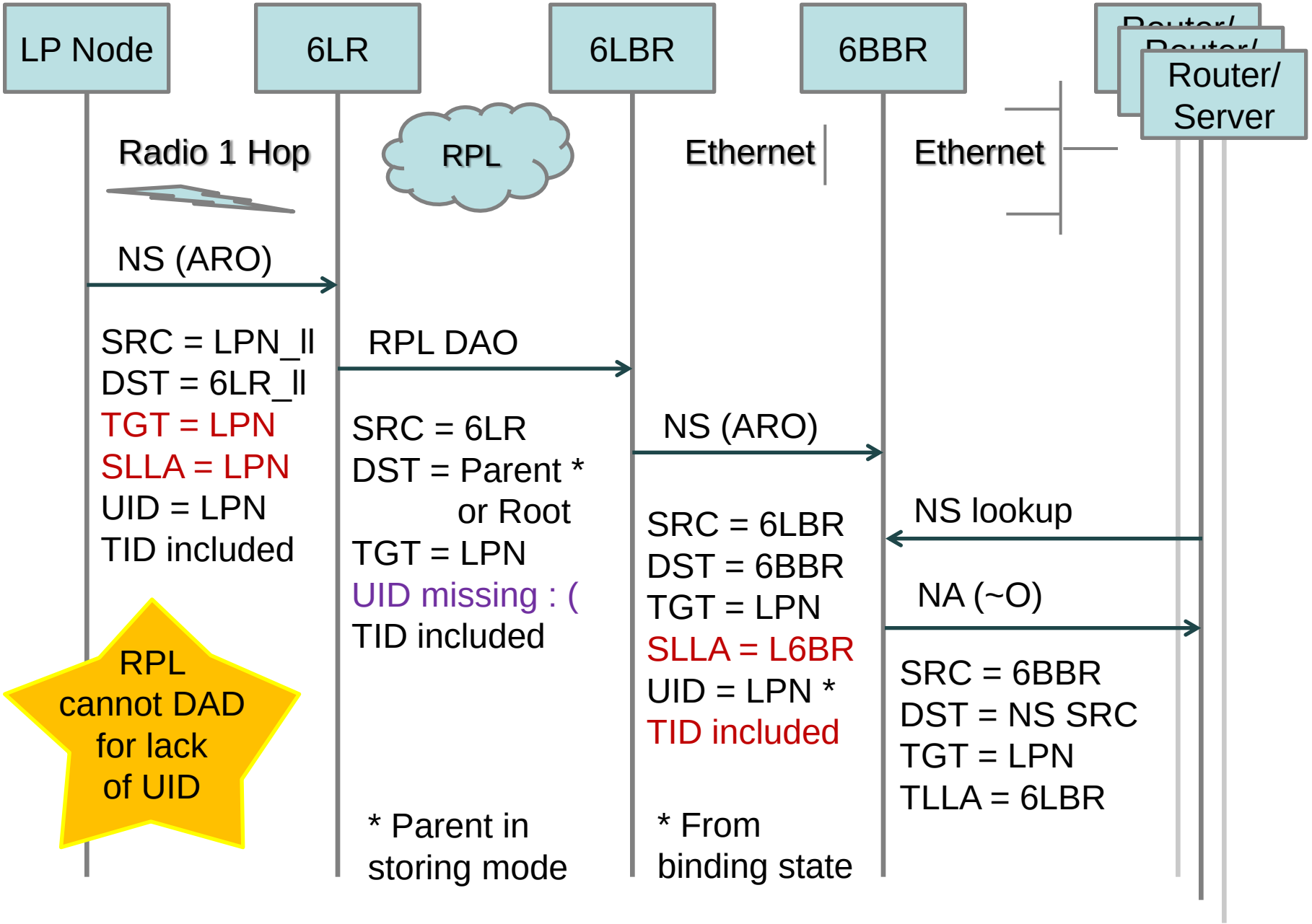
FLOWS IN FULL DISTRIBUTED MODE


ML Subnet
LP Node
6LR
6LBR
6BBR
Router/
Server
Radio 1 Hop
Radio
Mesh
Ethernet
Ethernet
6LoWPAN ND
RPL
Efficient ND
Classical ND
NS (ARO)
DAR, RPL DAO
NS (ARO)
NS DAD
NA (ARO)
Create proxy
state
DAC (ARO)
NA (ARO)
NS lookup
NA (~O)


LP Node
6LR
6LBR
6BBR
Router/
Server
Radio 1 Hop
RPL
Ethernet
Ethernet
RA (u|mcast)
PIO
MTU
RA (u|mcast)
PIO
MTU
SLLA
CONTEXT
RA (u|mcast)
PIO
MTU
SLLA
CONTEXT
RS (mcast)
SLLA
RA (unicast)
PIO
MTU
SLLA
CONTEXT
DIO
PIO
Can we avoid periodic RAs when we have DIO?

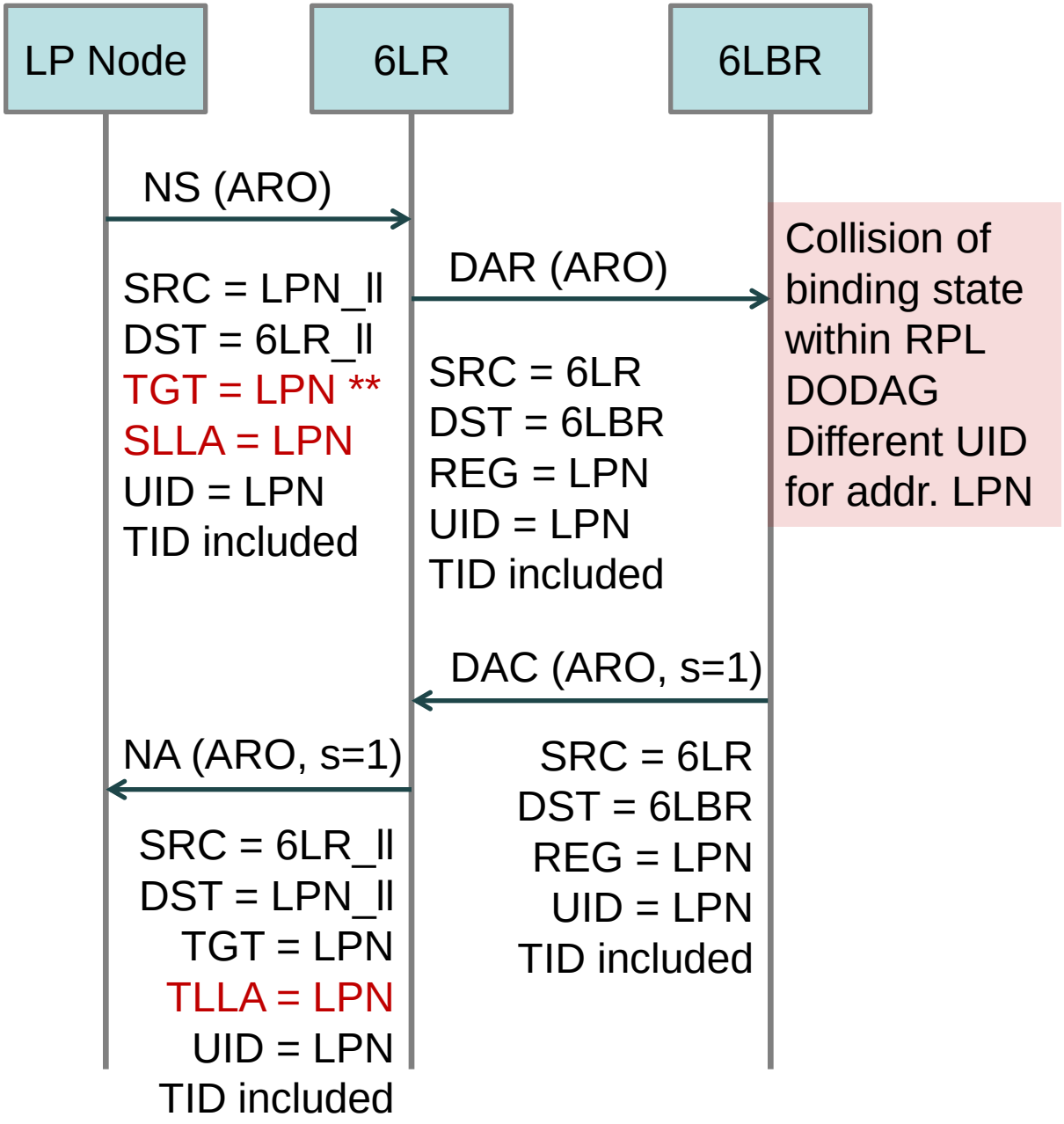

LP Node
6LR
6LBR
6BBR
Router/
Server
Radio 1 Hop
RPL
Ethernet
Ethernet
NS (ARO)
SRC = LPN_ll *
DST = 6LR_ll *
TGT = LPN **
SLLA = LPN
UID = LPN
TID included
SeND?
DAR (ARO)
SRC = 6LR *
DST = 6LBR
REG = LPN
UID = LPN
TID included
Create
binding state
NS (ARO)
SRC = 6LBR
DST = 6BBR *
TGT = LPN
SLLA = L6BR
= LPN
included
Create proxy
state
NS DAD (ARO)
SRC = UNSPEC
DST = SNMA
TGT = LPN
UID = LPN
TID included
RFC
6775 does not
use target
but src
* link local
unique EUI-64
** any LPN
IPv6 address
* Globa SLA
* Can be
Anycast

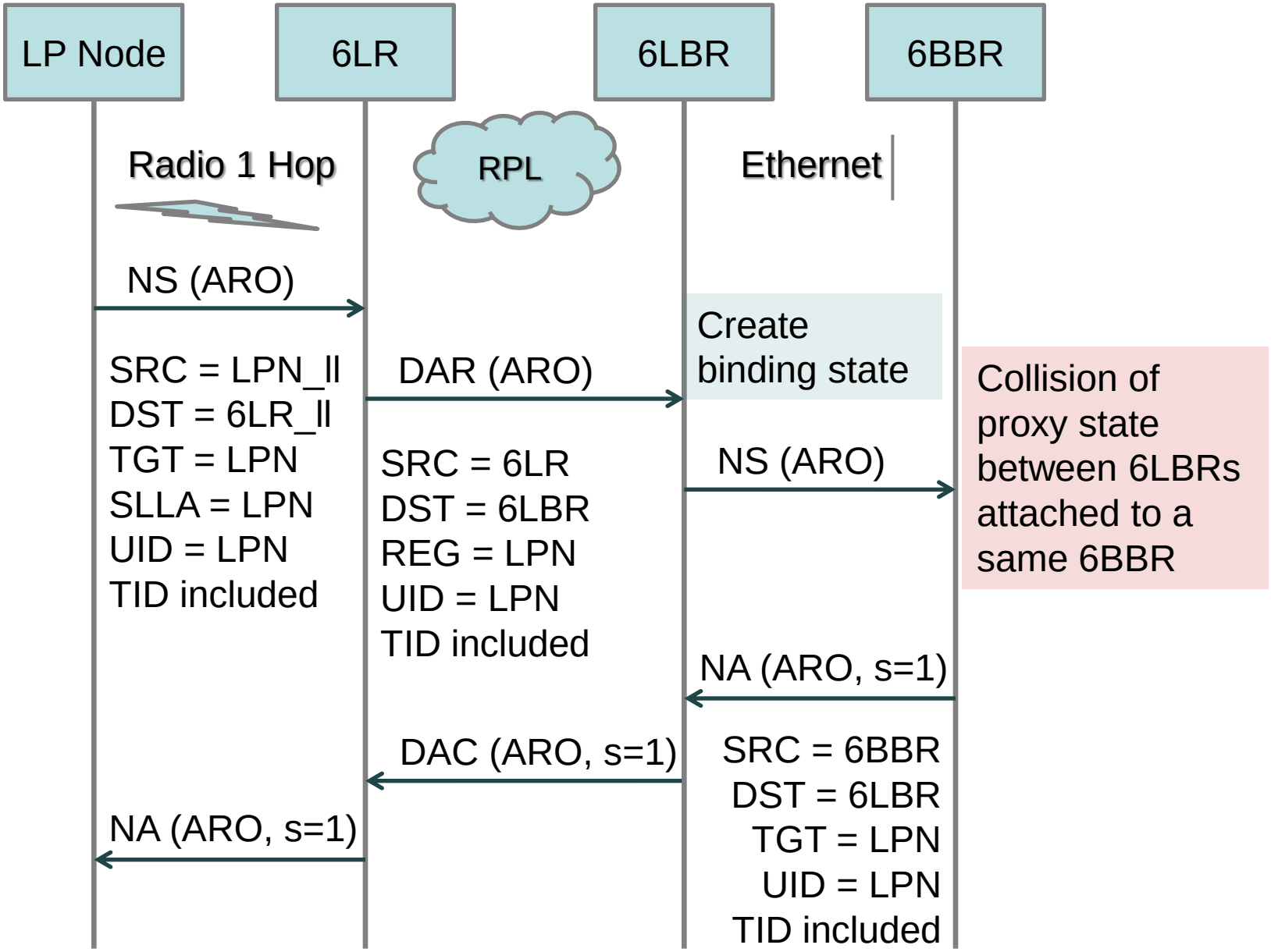

LP Node
6LR
6LBR
6BBR
Router/
Server
Radio 1 Hop
RPL
Ethernet
Ethernet
DAD time out
Adding TLLAO since dest. is not target
NA (O) *
NA (ARO)
SRC = 6BBR_ll **
DST = NS SRC
TLLA = L6BR
TGT = LPN
DAC (ARO)
SRC = 6BBR
DST = 6LBR
TGT = LPN
TLLA = L6BR
UID = LPN
TID included
NA (ARO)
SRC = 6LR
DST = 6LBR
REG = LPN
UID = LPN
TID included
SRC = 6LR_ll
DST = LPN_ll
TGT = LPN
TLLA = LPN?
UID = LPN
TID included
* Omitted in general
** link local

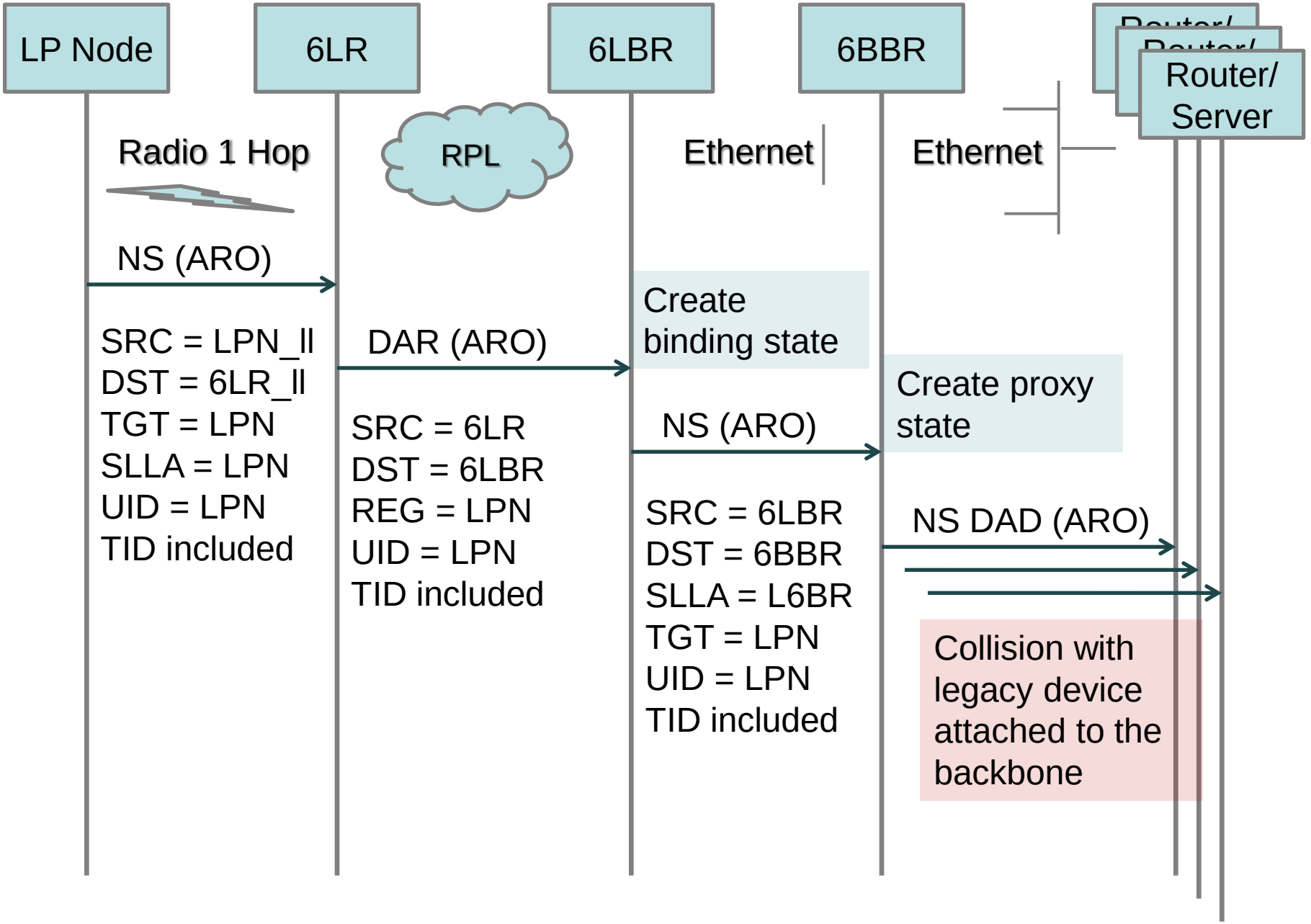

LP Node
6LR
6LBR
6BBR
Router/
Server
Radio 1 Hop
RPL
Ethernet
Ethernet
NS (ARO)
SRC = LPN_ll
DST = 6LR_ll
TGT = LPN
SLLA = LPN
UID = LPN
TID included
RPL DAO
SRC = 6LR
DST = Parent *
or Root
TGT = LPN
UID missing : (
TID included
NS (ARO)
SRC = 6LBR
DST = 6BBR
TGT = LPN
SLLA = L6BR
UID = LPN *
TID included
NS lookup
NA (~O)
SRC = 6BBR
DST = NS SRC
TGT = LPN
TLLA = 6LBR
RPL
cannot DAD
for lack
of UID
* Parent in
storing mode
* From
binding state

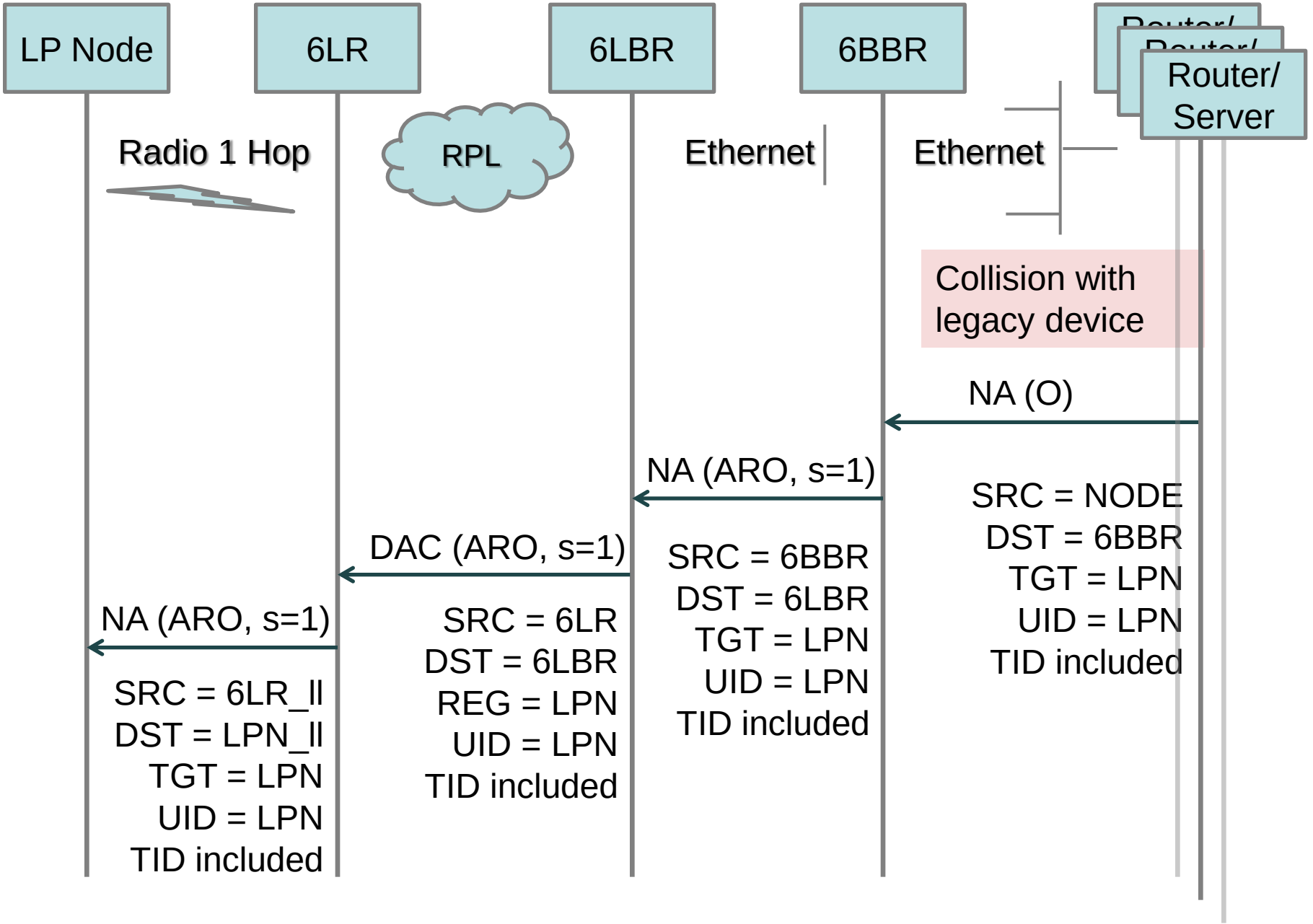
Duplicate registration

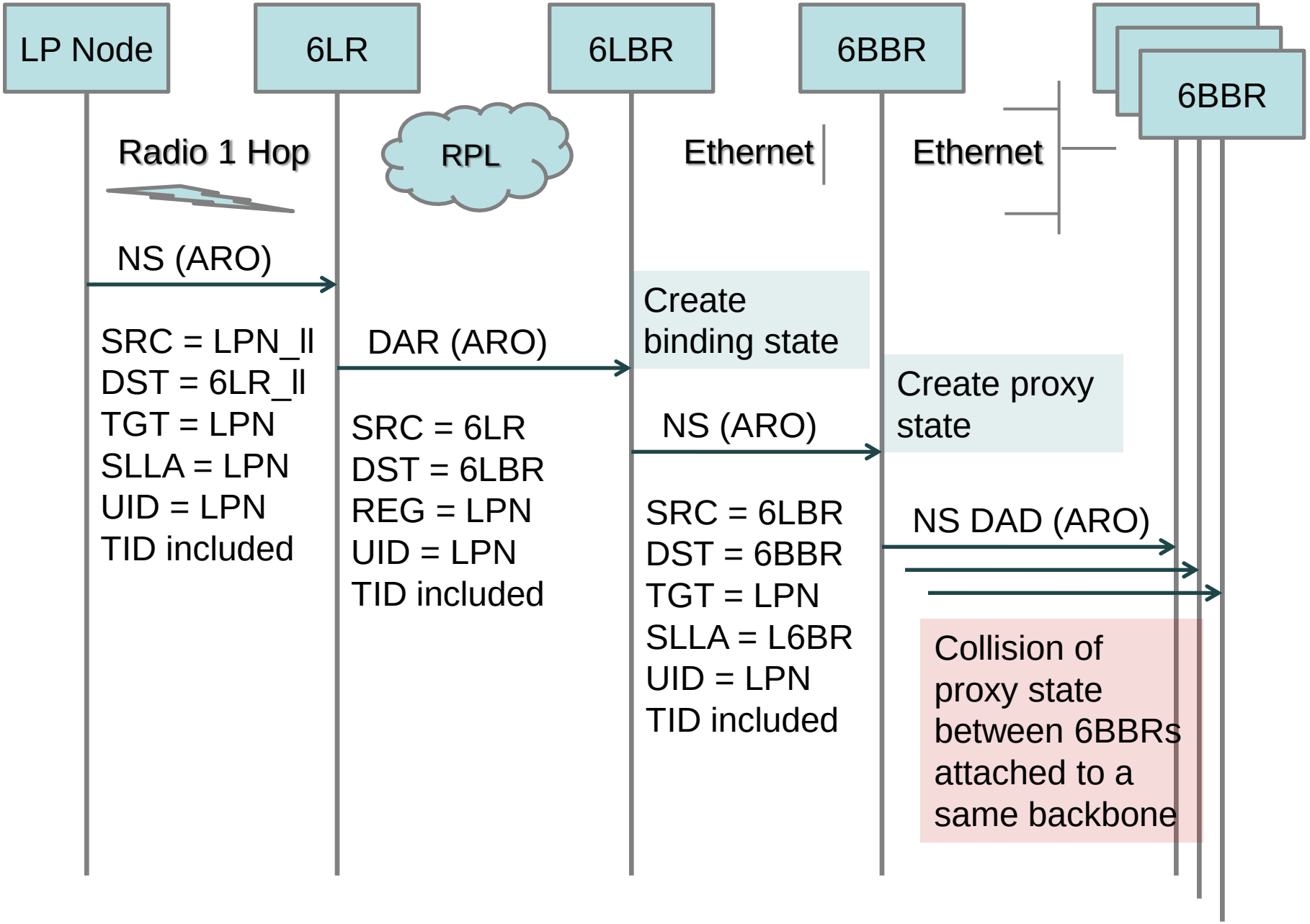
FLOWS IN FULL DISTRIBUTED MODE

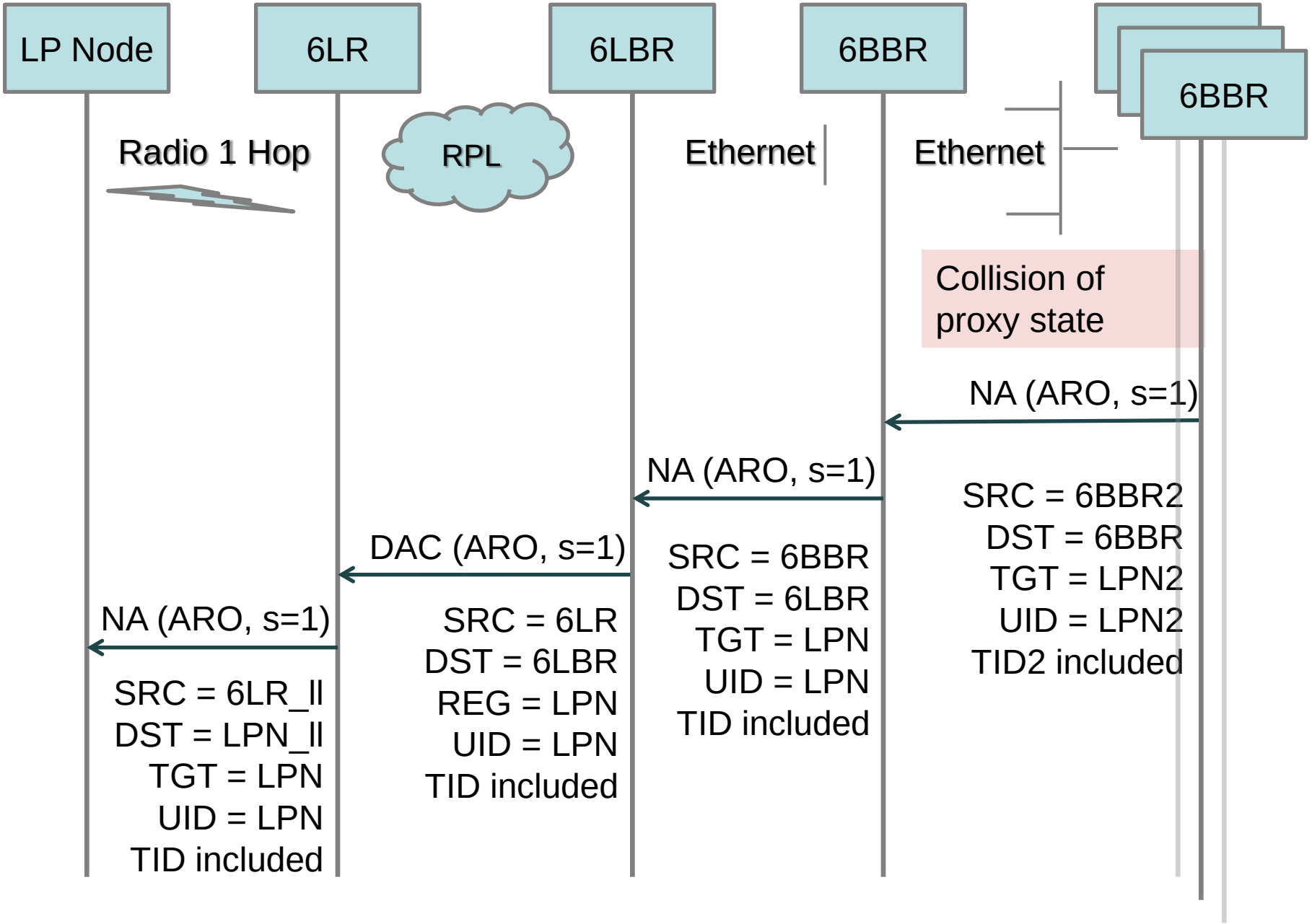

LP Node
6LR
6LBR
NS (ARO)
SRC = LPN_ll
DST = 6LR_ll
TGT = LPN **
SLLA = LPN
UID = LPN
TID included
DAR (ARO)
SRC = 6LR
DST = 6LBR
REG = LPN
UID = LPN
TID included
Collision of binding state within RPL DODAG Different UID for addr. LPN
DAC (ARO, s=1)
SRC = 6LR
DST = 6LBR
REG = LPN
UID = LPN
TID included
NA (ARO, s=1)
SRC = 6LR_ll
DST = LPN_ll
TGT = LPN
TLLA = LPN
UID = LPN
TID included


LP Node
6LR
6LBR
6BBR
Radio 1 Hop
RPL
Ethernet
NS (ARO)
SRC = LPN_ll
DST = 6LR_ll
TGT = LPN
SLLA = LPN
UID = LPN
TID included
DAR (ARO)
SRC = 6LR
DST = 6LBR
REG = LPN
UID = LPN
TID included
Create binding state
NS (ARO)
Collision of proxy state between 6LBRs attached to a same 6BBR
NA (ARO, s=1)
SRC = 6BBR
DST = 6LBR
TGT = LPN
UID = LPN
TID included
DAC (ARO, s=1)
NA (ARO, s=1)


LP Node
6LR
6LBR
6BBR
Router/
Server
Radio 1 Hop
RPL
Ethernet
Ethernet
NS (ARO)
SRC = LPN_ll
DST = 6LR_ll
TGT = LPN
SLLA = LPN
UID = LPN
TID included
DAR (ARO)
SRC = 6LR
DST = 6LBR
REG = LPN
UID = LPN
TID included
Create
binding state
NS (ARO)
SRC = 6LBR
DST = 6BBR
SLLA = L6BR
TGT = LPN
UID = LPN
TID included
Create proxy
state
NS DAD (ARO)
Collision with
legacy device
attached to the
backbone

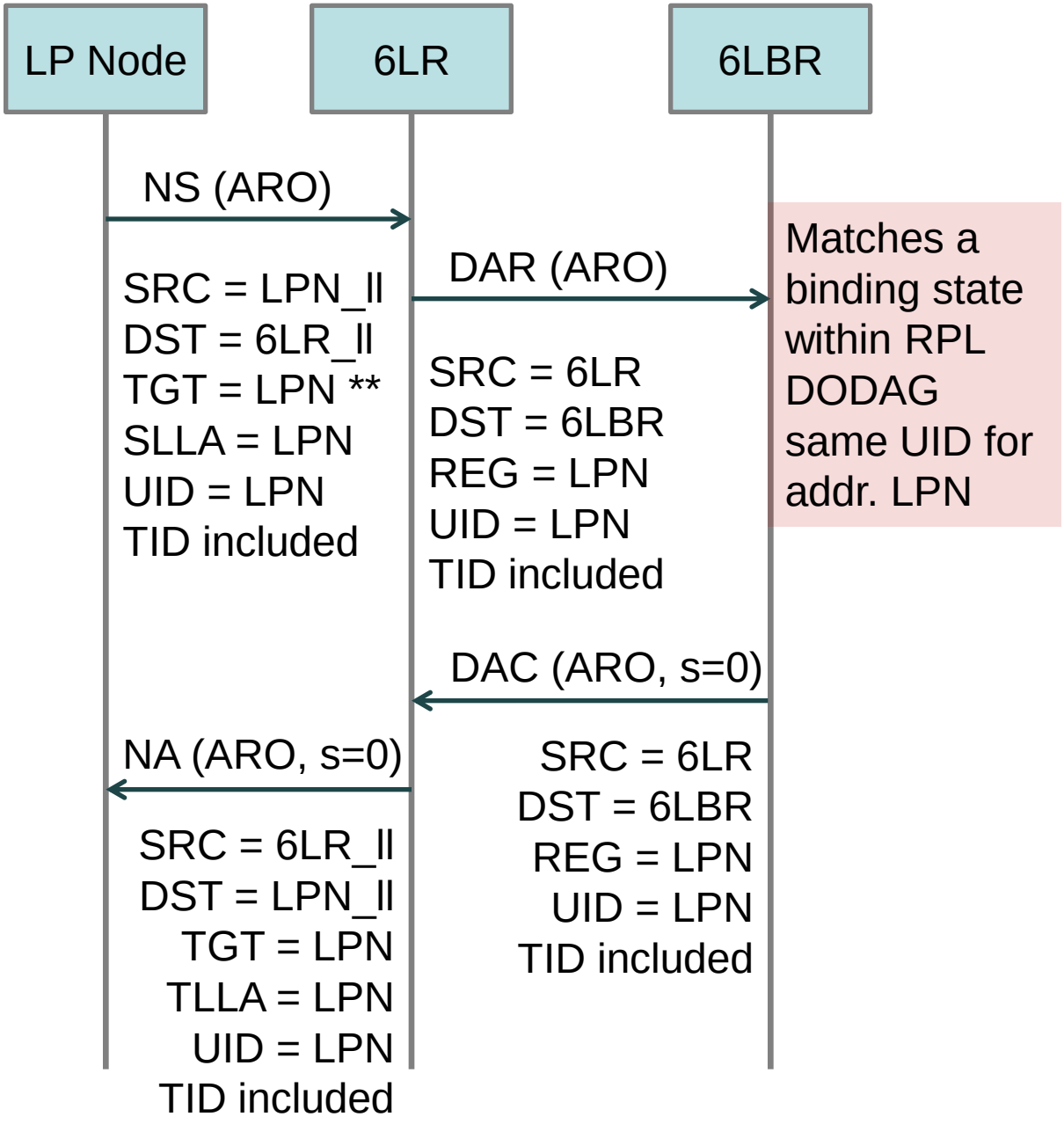

LP Node
6LR
6LBR
6BBR
Router/
Server
Radio 1 Hop
RPL
Ethernet
Ethernet
Collision with
legacy device
NA (O)
SRC = NODE
DST = 6BBR
TGT = LPN
UID = LPN
TID included
NA (ARO, s=1)
SRC = 6BBR
DST = 6LBR
TGT = LPN
UID = LPN
TID included
DAC (ARO, s=1)
SRC = 6LR
DST = 6LBR
REG = LPN
UID = LPN
TID included
NA (ARO, s=1)
SRC = 6LR_ll
DST = LPN_ll
TGT = LPN
UID = LPN
TID included

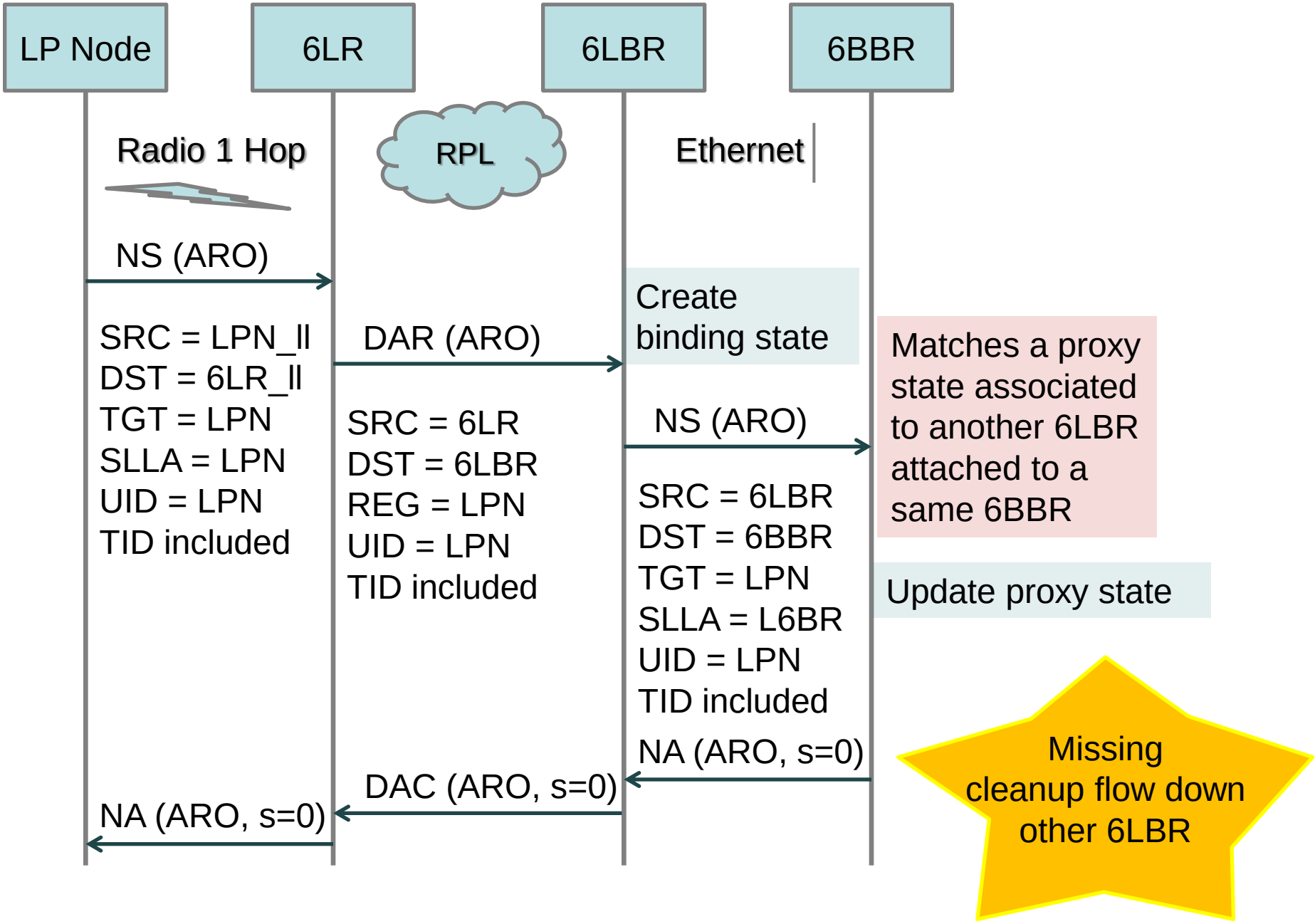

LP Node
6LR
6LBR
6BBR
6BBR
Radio 1 Hop
RPL
Ethernet
Ethernet
NS (ARO)
SRC = LPN_ll
DST = 6LR_ll
TGT = LPN
SLLA = LPN
UID = LPN
TID included
DAR (ARO)
SRC = 6LR
DST = 6LBR
REG = LPN
UID = LPN
TID included
Create binding state
NS (ARO)
SRC = 6LBR
DST = 6BBR
TGT = LPN
SLLA = L6BR
UID = LPN
TID included
Create proxy state
NS DAD (ARO)
Collision of proxy state between 6BBRs attached to a same backbone

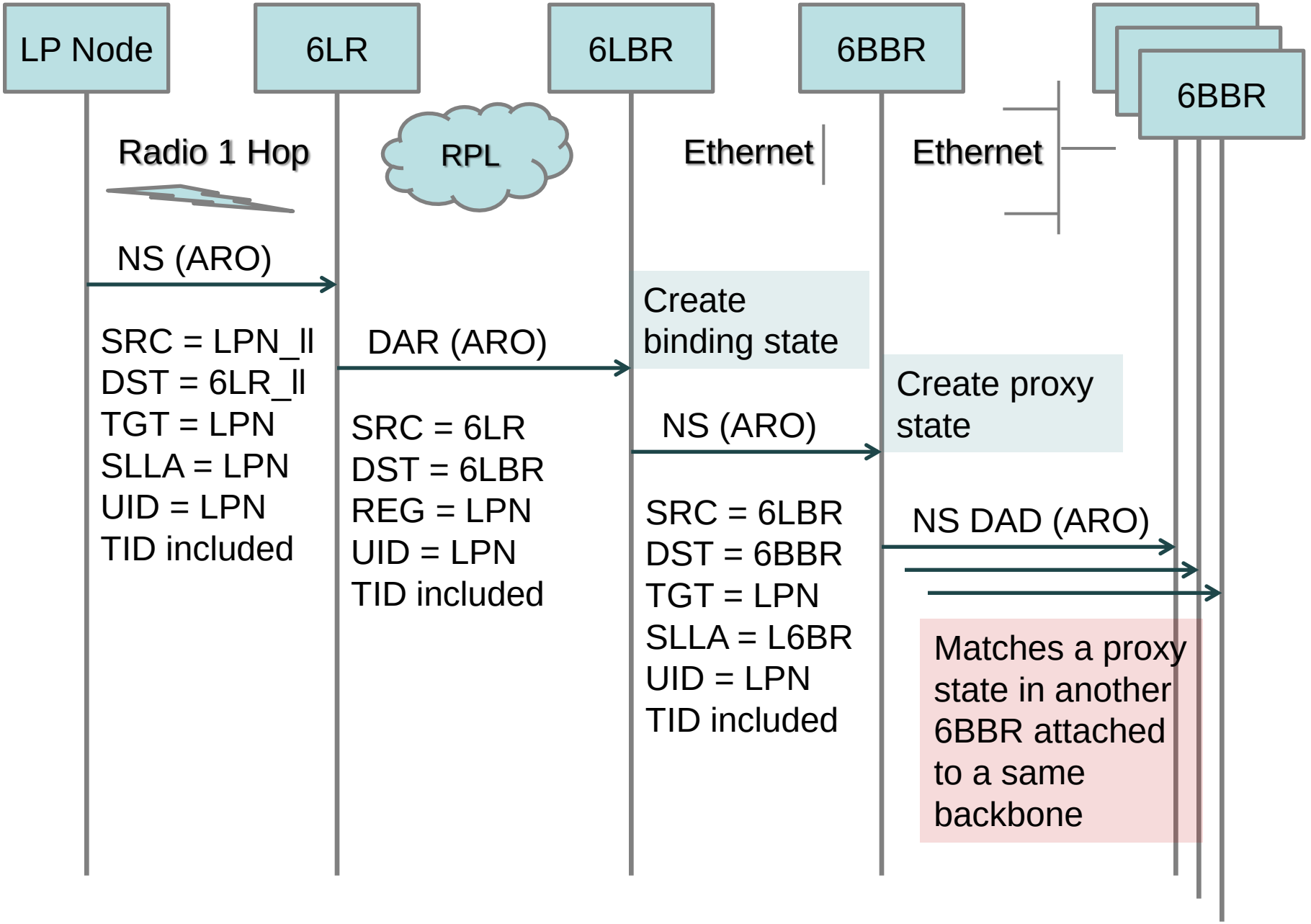

LP Node
6LR
6LBR
6BBR
6BBR
Radio 1 Hop
RPL
Ethernet
Ethernet
Collision of proxy state
NA (ARO, s=1)
SRC = 6BBR2
DST = 6BBR
TGT = LPN2
UID = LPN2
TID2 included
NA (ARO, s=1)
SRC = 6BBR
DST = 6LBR
TGT = LPN
UID = LPN
TID included
DAC (ARO, s=1)
SRC = 6LR
DST = 6LBR
REG = LPN
UID = LPN
TID included
NA (ARO, s=1)
SRC = 6LR_ll
DST = LPN_ll
TGT = LPN
UID = LPN
TID included

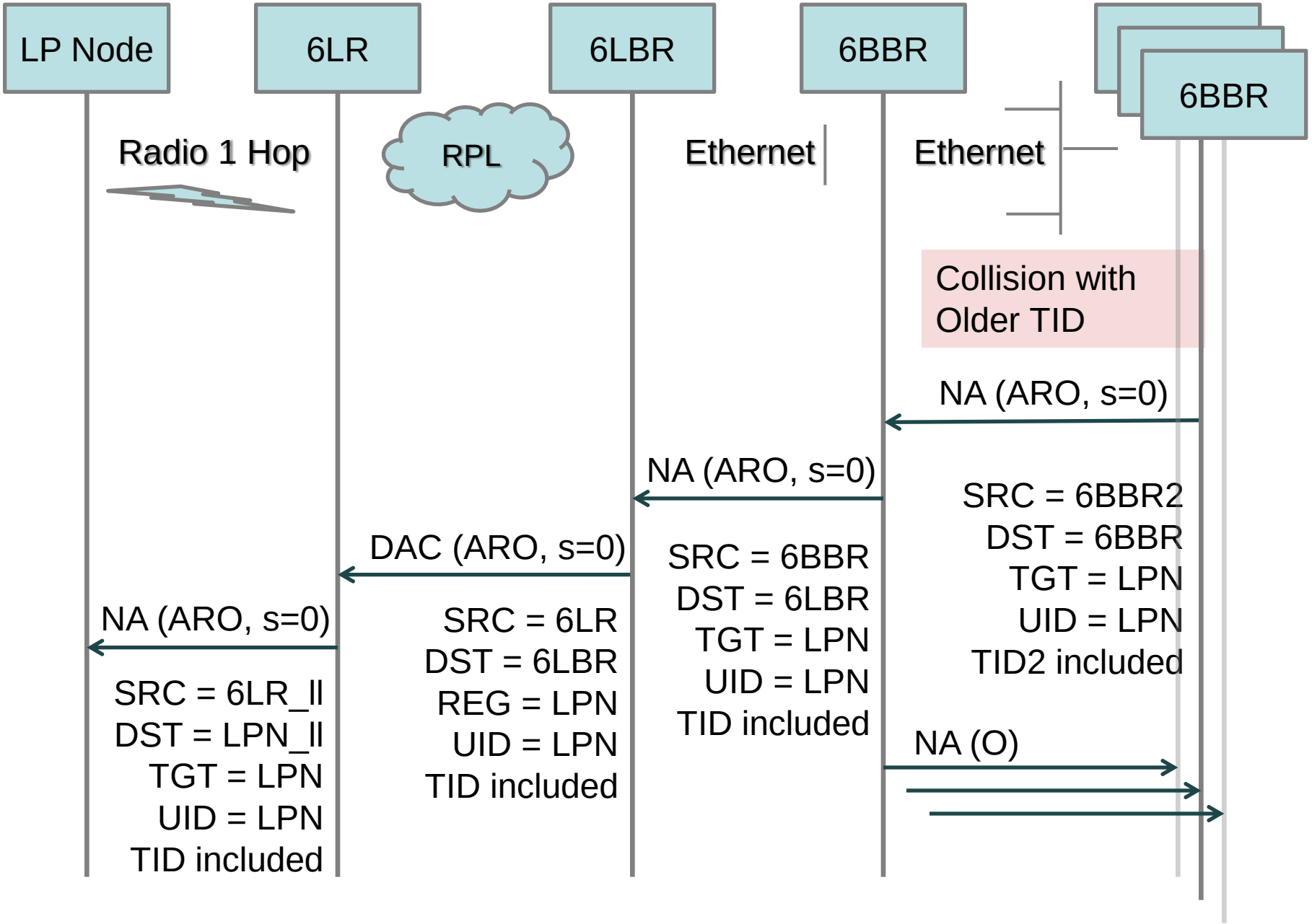
Movements

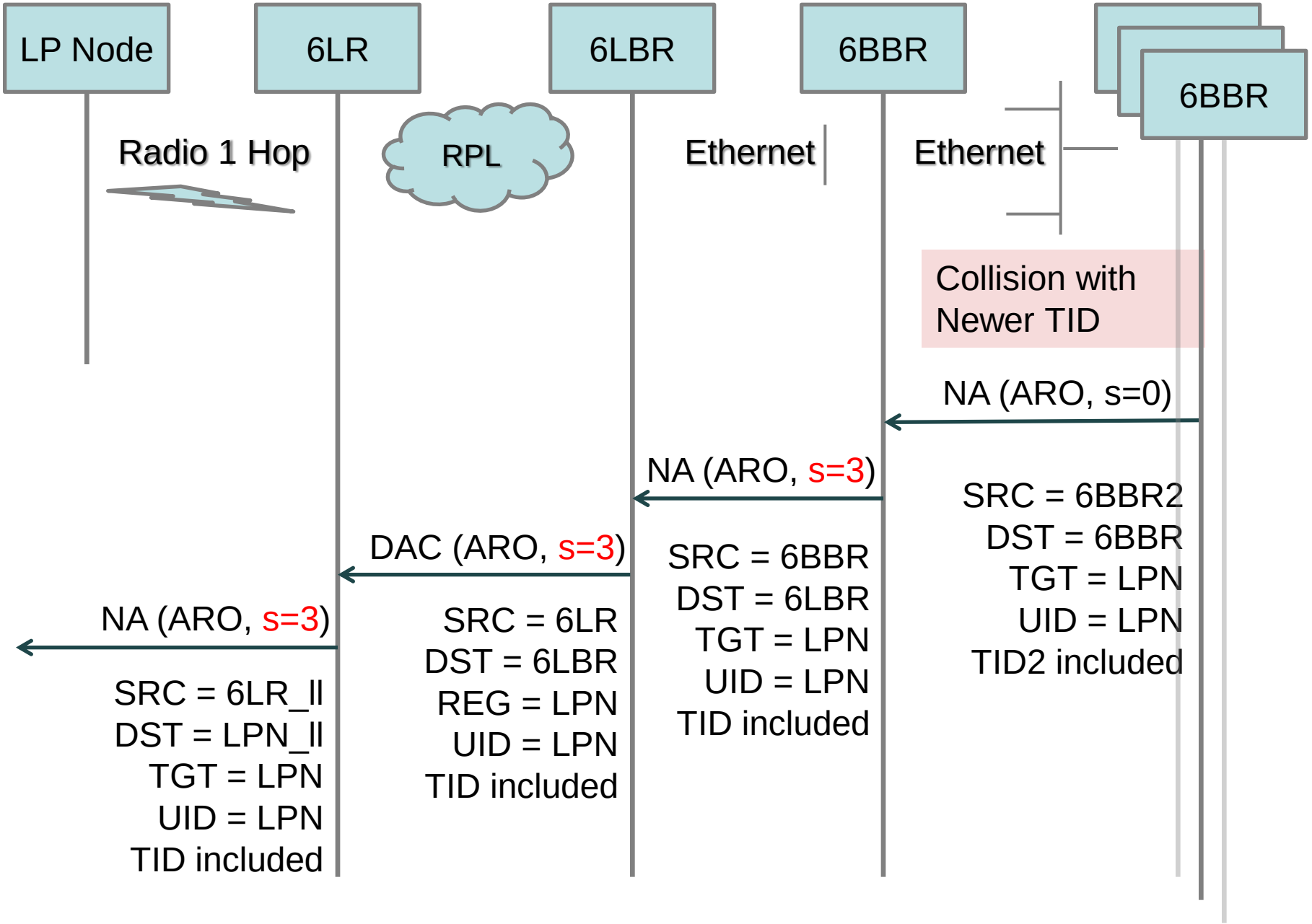
FLOWS IN FULL DISTRIBUTED MODE


LP Node
6LR
6LBR
NS (ARO)
SRC = LPN_ll
DST = 6LR_ll
TGT = LPN **
SLLA = LPN
UID = LPN
TID included
DAR (ARO)
SRC = 6LR
DST = 6LBR
REG = LPN
UID = LPN
TID included
Matches a binding state within RPL DODAG same UID for addr. LPN
DAC (ARO, s=0)
SRC = 6LR
DST = 6LBR
REG = LPN
UID = LPN
TID included
NA (ARO, s=0)
SRC = 6LR_ll
DST = LPN_ll
TGT = LPN
TLLA = LPN
UID = LPN
TID included

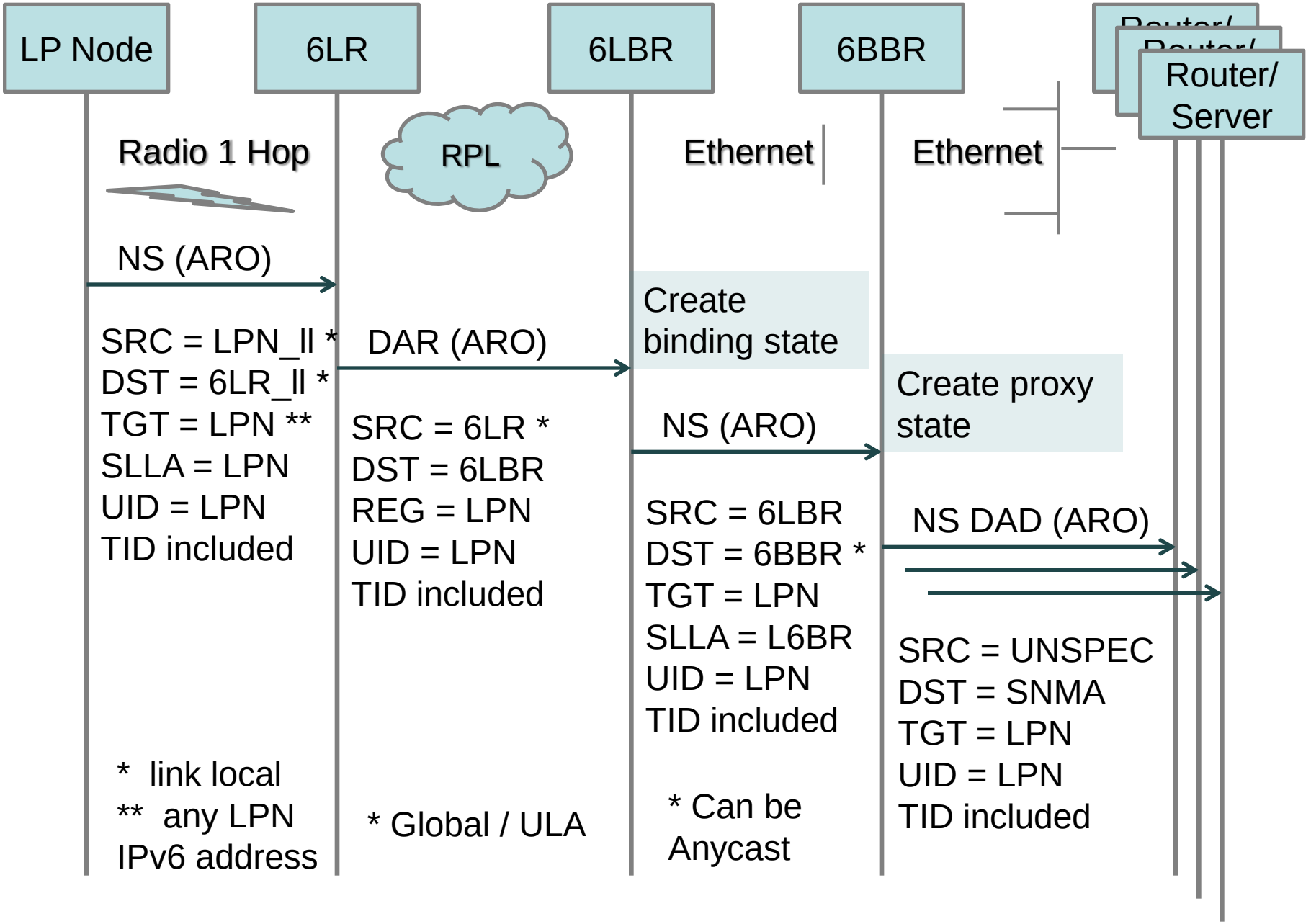

LP Node
6LR
6LBR
6BBR
Radio 1 Hop
RPL
Ethernet
NS (ARO)
SRC = LPN_ll
DST = 6LR_ll
TGT = LPN
SLLA = LPN
UID = LPN
TID included
DAR (ARO)
SRC = 6LR
DST = 6LBR
REG = LPN
UID = LPN
TID included
Create binding state
NS (ARO)
SRC = 6LBR
DST = 6BBR
TGT = LPN
SLLA = L6BR
UID = LPN
TID included
Matches a proxy state associated to another 6LBR attached to a same 6BBR
Update proxy state
NA (ARO, s=0)
DAC (ARO, s=0)
NA (ARO, s=0)
Missing cleanup flow down other 6LBR

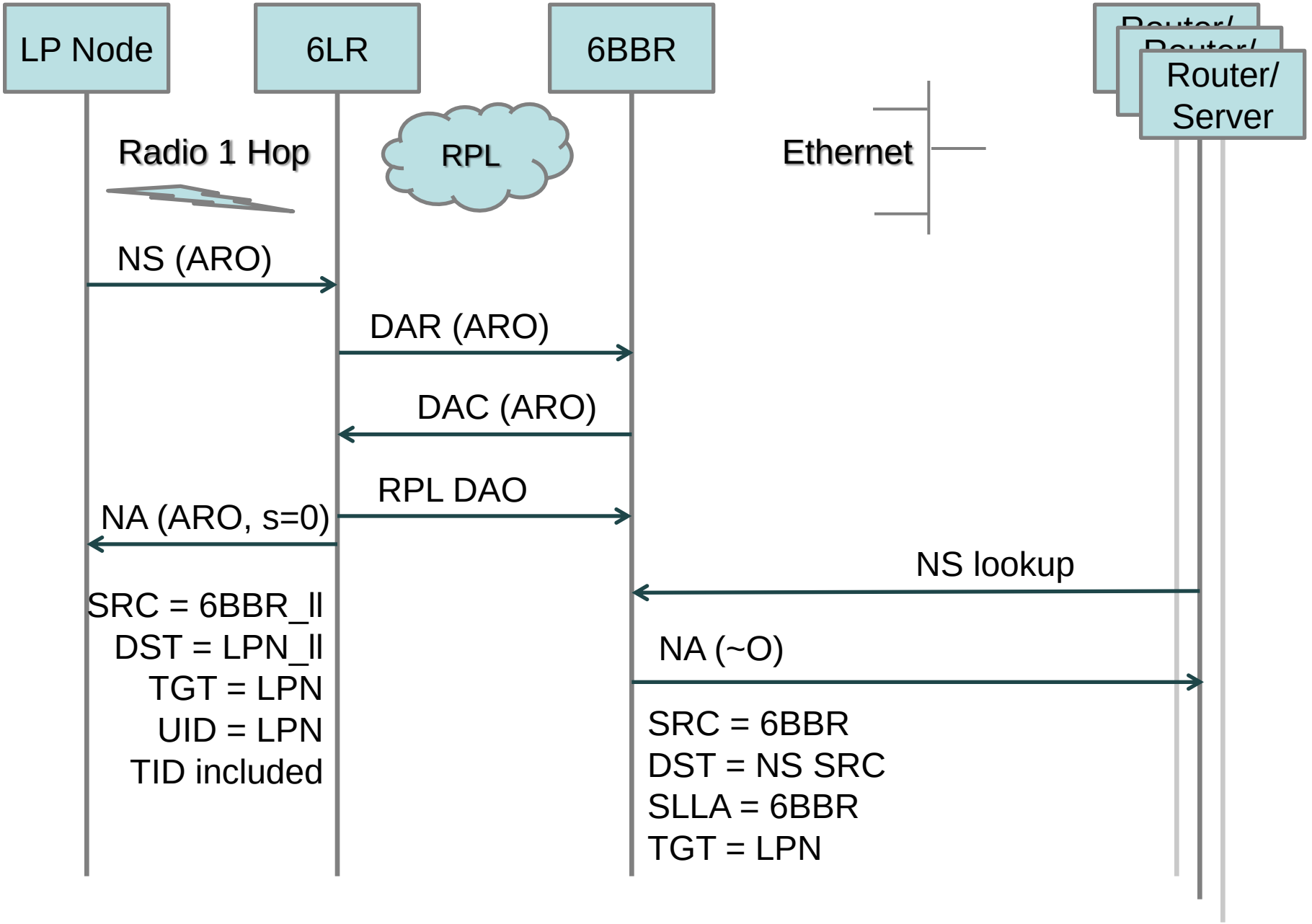

LP Node
6LR
6LBR
6BBR
6BBR
Radio 1 Hop
RPL
Ethernet
Ethernet
NS (ARO)
SRC = LPN_ll
DST = 6LR_ll
TGT = LPN
SLLA = LPN
UID = LPN
TID included
DAR (ARO)
SRC = 6LR
DST = 6LBR
REG = LPN
UID = LPN
TID included
Create binding state
NS (ARO)
SRC = 6LBR
DST = 6BBR
TGT = LPN
SLLA = L6BR
UID = LPN
TID included
Create proxy state
NS DAD (ARO)
Matches a proxy state in another 6BBR attached to a same backbone


LP Node
6LR
6LBR
6BBR
6BBR
Radio 1 Hop
RPL
Ethernet
Ethernet
Collision with
Older TID
NA (ARO, s=0)
NA (ARO, s=0)
SRC = 6BBR2
DST = 6BBR
TGT = LPN
UID = LPN
TID2 included
DAC (ARO, s=0)
SRC = 6BBR
DST = 6LBR
TGT = LPN
UID = LPN
TID included
NA (ARO, s=0)
SRC = 6LR
DST = 6LBR
REG = LPN
UID = LPN
TID included
SRC = 6LR_ll
DST = LPN_ll
TGT = LPN
UID = LPN
TID included
NA (O)


LP Node
6LR
6LBR
6BBR
6BBR
Radio 1 Hop
RPL
Ethernet
Ethernet
Collision with
Newer TID
NA (ARO, s=0)
SRC = 6BBR2
DST = 6BBR
TGT = LPN
UID = LPN
TID2 included
NA (ARO, s=3)
SRC = 6BBR
DST = 6LBR
TGT = LPN
UID = LPN
TID included
DAC (ARO, s=3)
SRC = 6LR
DST = 6LBR
REG = LPN
UID = LPN
TID included
NA (ARO, s=3)
SRC = 6LR_ll
DST = LPN_ll
TGT = LPN
UID = LPN
TID included

FLOWS IF 6LBR COLLAPSED WITH 6BBR


LP Node
6LR
6LBR
6BBR
Router/
Server
Radio 1 Hop
RPL
Ethernet
Ethernet
NS (ARO)
SRC = LPN_ll *
DST = 6LR_ll *
TGT = LPN **
SLLA = LPN
UID = LPN
TID included
DAR (ARO)
SRC = 6LR *
DST = 6LBR
REG = LPN
UID = LPN
TID included
Create
binding state
NS (ARO)
SRC = 6LBR
DST = 6BBR *
TGT = LPN
SLLA = L6BR
UID = LPN
TID included
Create proxy
state
NS DAD (ARO)
SRC = UNSPEC
DST = SNMA
TGT = LPN
UID = LPN
TID included
* link local
** any LPN
IPv6 address
* Global / ULA
* Can be
Anycast


LP Node
6LR
6BBR
Router/
Server
Radio 1 Hop
RPL
Ethernet
NS (ARO)
DAR (ARO)
DAC (ARO)
RPL DAO
NA (ARO, s=0)
NS lookup
SRC = 6BBR_ll
DST = LPN_ll
TGT = LPN
UID = LPN
TID included
NA (~O)
SRC = 6BBR
DST = NS SRC
SLLA = 6BBR
TGT = LPN

Thank you!