# Neighbor Management Policy for 6LoWPAN:

Issues, state-of-art, recommendations

Rahul, Rabi@ Huawei

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Why Neighbor Management?

- Challenges
  - Unknown network size , unknown Node density
  - Constrained networks with limited neighbor table cache
- Current Neighbor Management policies
  - Evict LRU entry [Contiki]
  - First come first serve [RiOT]
- Expectation of neighbor management
  - Deterministic behavior, should not result in route downtime.
  - Finally the network should be formed with any node density.
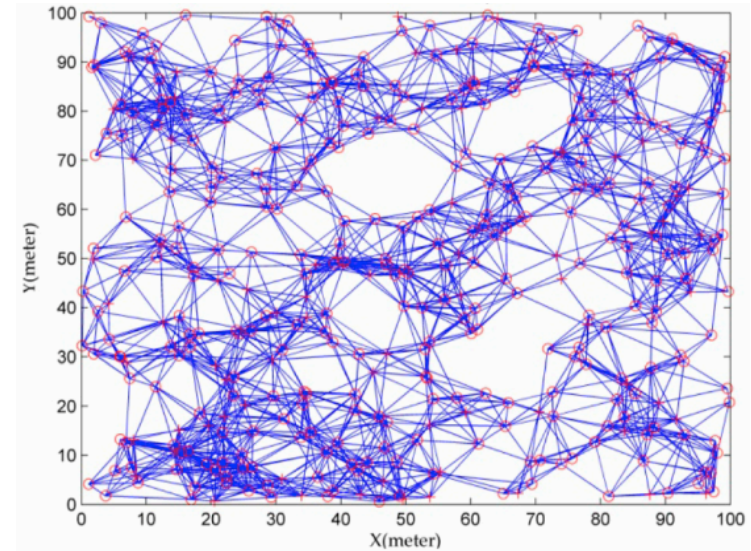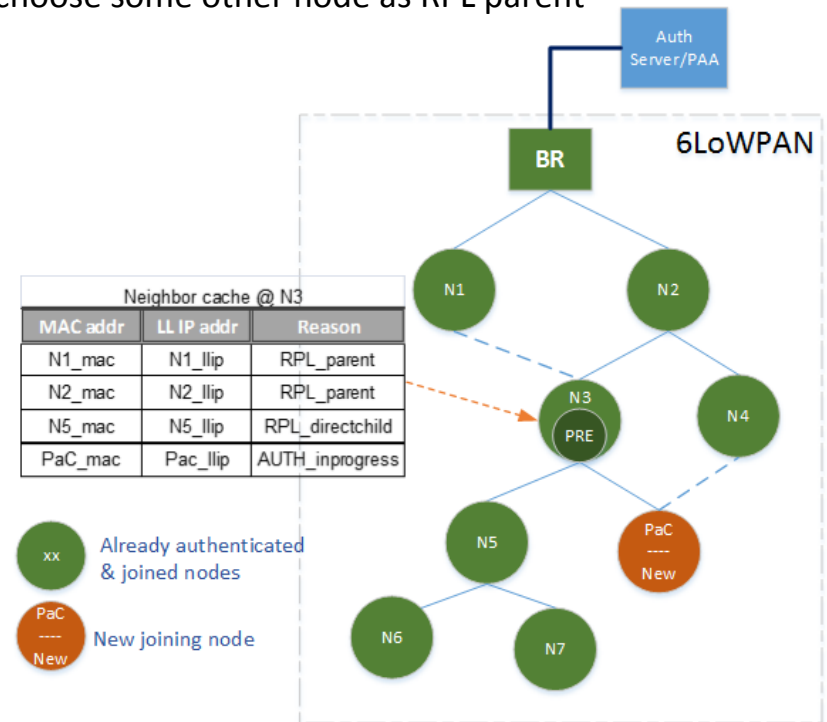
Literature Analysis
    [1]On Link Estimation in Dense RPL deployment – Dawans et.al.
    [2]Taming the underlying challenges of reliable multihop routing in sensor networks – Woo et.al.

Holistic approach towards neighbor management

- An example security-enabled 6LoWPAN/RPL network
  - Key management protocols before RPL network formation
    - PANA based example, used by Wi-SUN

- Cases where neighbor table update happens,
  - Relay based signaling during authentication
    - PRE selection by PaC, usually involves discovery messaging
    - PRE needs to add PaC as a neighbor since it will act as security forwarder till the authentication process completes
    - Note that post-authentication-success, PaC may choose some other node as RPL parent
  - RPL's parent selection using DIO messaging
  - RPL's routing direct child node
    - Using DAO messaging
    - Note RPL_directchild

Neighbor cache @ N3		
MAC addr	LL IP addr	Reason
N1_mac	N1_llip	RPL_parent
N2_mac	N2_llip	RPL_parent
N5_mac	N5_llip	RPL_directchild
PaC_mac	Pac_llip	AUTH_inprogress

Auth Server/PAA

BR   6LoWPAN

N1   N2

N3
PRE   N4

N5   PaC ---- New

N6   N7

xx Already authenticated & joined nodes

PaC ---- New New joining node

Neighbor Management Operations

- **Insertion**
  - Problem with simple logic (If table space is available insert)
    - RPL's DIO storm in dense network may overwhelm neighbor cache
    - Parent selection procedure may result in a single parent been chosen by all the nodes resulting in neighbor cache containing only routing direct child entries.
    - Similarly PRE discovery may result in the same PRE been made use of by several PaC.

- **Eviction**
  - Issues with eviction
    - A routing direct child is difficult to evict since in storing-mode it will have ripple effect i.e. all grand-childs also have to change path in turn.
    - Similarly if a PaC is added to neighbor cache, then early eviction may result in neighbor churn.
  - Evicting non-preferred parent information is usually possible without much immediate implications
    - For e.g. on receiving DAO, one can evict a "least-effective" parent entry from neighbor table
    - Effectiveness of a parent entry may be determined by factor such as link quality.

- **Reinforcement**[1]
  - The selected links in neighbor cache needs to be reinforced
    - Reinforcement can be done on passive/active hearing
  - Reinforcement allows the link quality estimation to be updated, eventually helping in eviction decision

[1] Taming the Underlying Challenges of Reliable Multihop Routing in Sensor Networks, Woo et.al.

Clearing unused Neighbor table entries

- Important that unused neighbor table entries be cleared soon.
- Route invalidation is important since routing entries are mapped to neighbor entries
- PRE neighbors
  - After authentication is successful, the PRE auth entries can be removed.
  - However there is no way of explicit identification of the finish of auth
  - Usually reachability timeout will remove such entries. For neighbors added during authentication, the reachability timer can be reduced to a lower value.

Recommendations

- Basic principles
  - Reservation of routing direct child entries
    - Note that these are for direct child routing entries only.
  - Reservation of relay element entries
  - Parent node's entries can be inserted at will and can occupy reserved entries
    - Because parent entries could be evicted if necessary, unlike routing direct childs and relay element entries
- Graceful rejection of DAO/PANA messages
  - NACK for rejecting DAO
  - PANA client requests can be rejected by PAR message with Result-Code AVP
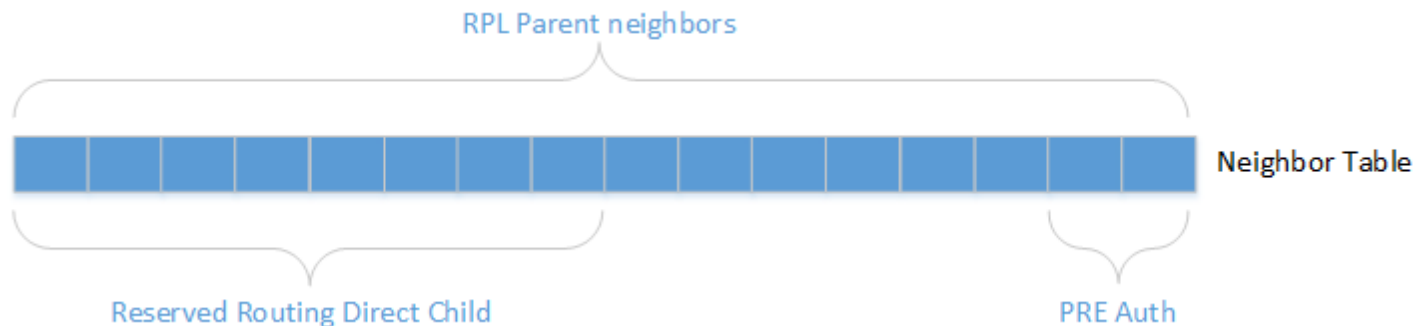
Impact of neighbor management policy

- A neighbor management policy may result in the increase of convergence time

- Eventually the hops in the network will increase
  - Resulting in more over-the-air packets

- Everything is a trade-off :
  - The overall outcome of the neighbor management policy is to have a deterministic (but may not be optimal) behavior.

Without nbr mgmt, assuming enough nbr table size

With nbr mgmt, assuming max 3 nbr entries
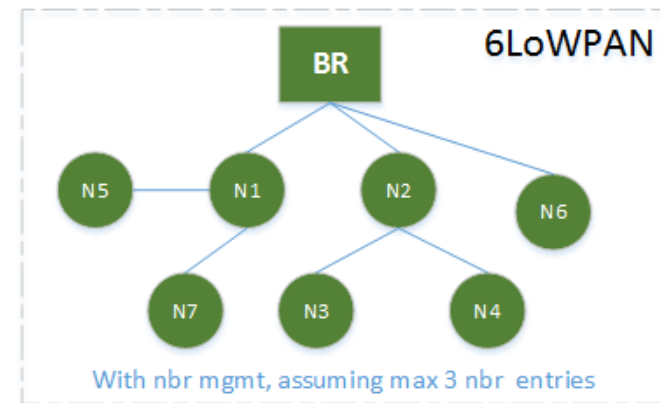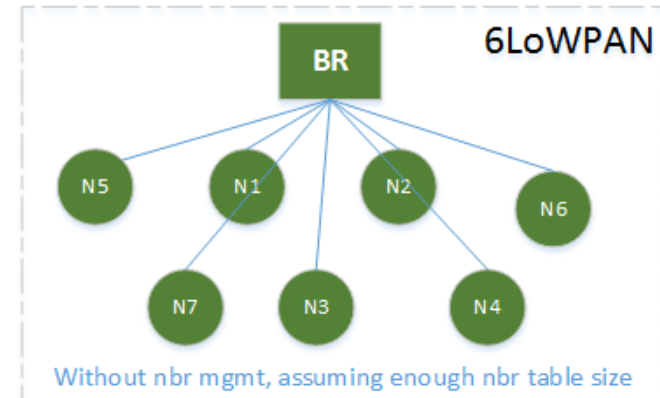
Discussions

- Did you meet the same problems in your implementations ? If so, how do you tackle them?

- Plan: a draft submission on this topic short after IETF97
  - collaborators welcome