

PAW

Exploiting Packet Replication and Elimination in Complex Tracks in LLNs

draft-papadopoulos-paw-pre-reqs-01

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Authors: G. Papadopoulos, R. Koutsiamanis, N. Montavont and P. Thubert

PAW - IETF 104 - Prague

Outline

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- ⇒ Motivation
- ⇒ PRE Functions
- ⇒ PRE Requirements
- ⇒ Alternative Parent Selection modes
- ⇒ Recent Results

Outline

draft-papadopoulos-paw-pre-reqs-01 : 24/03/2019

⇒ *Motivation*

⇒ PRE Functions

⇒ PRE Requirements

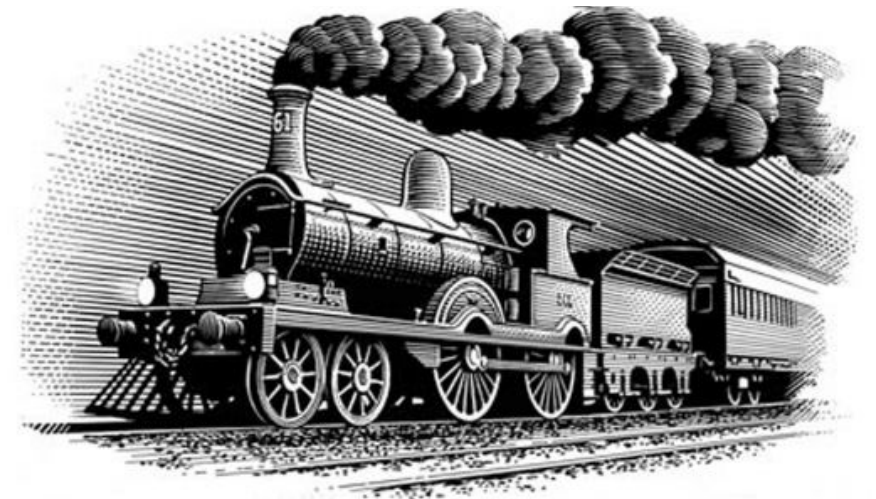
⇒ Alternative Parent Selection modes

⇒ Recent Results

Toward Robust and Predictable Communication

Motivation :

- ⇒ Reliable communication
- ⇒ Guaranteed maximum (bounded) latency
- ⇒ Ultra-low jitter performance



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⇒ Motivation

⇒ *PRE Functions*

⇒ PRE Requirements

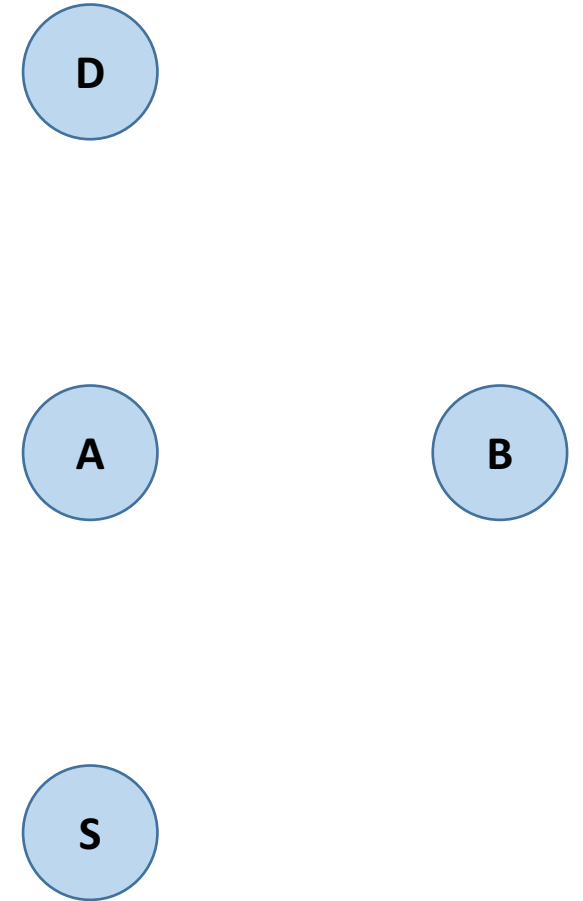
⇒ Alternative Parent Selection modes

⇒ Recent Results

Wireless Topology of 2 hops

Topology :

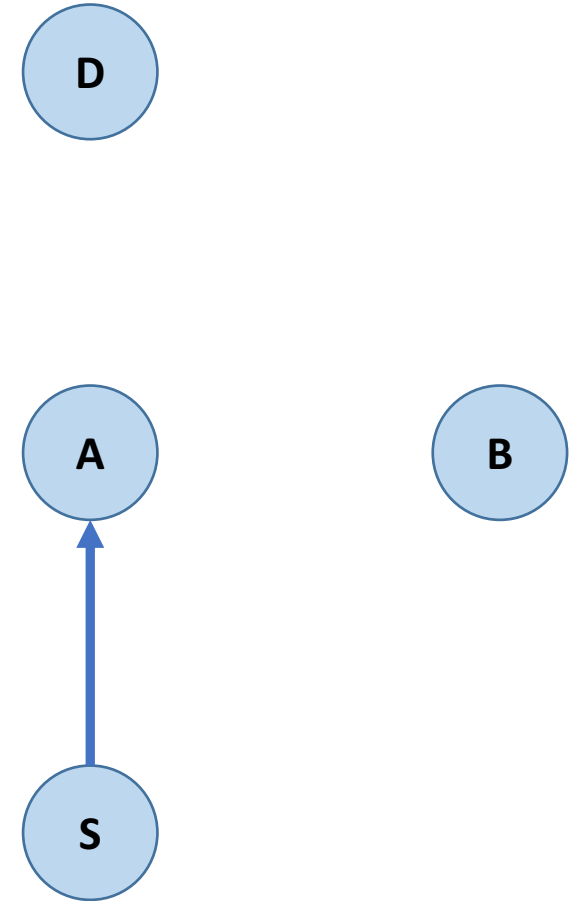
- ⇒ S is the source device;
- ⇒ D is the destination device;
- ⇒ A and B are the relay devices.



Packet Replication

Replication :

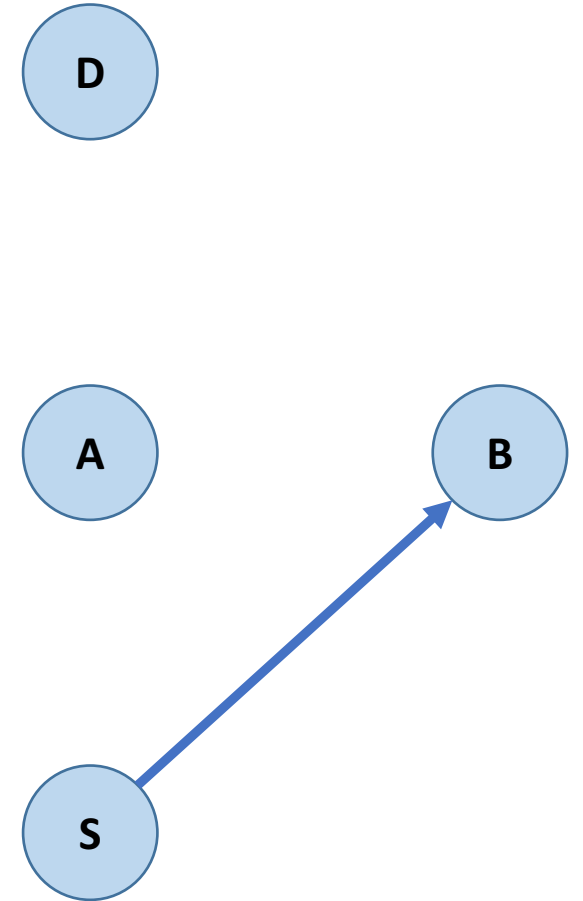
⇒ Data packet is transmitted to both
Default & “Alternate” Parents



Packet Replication

Replication :

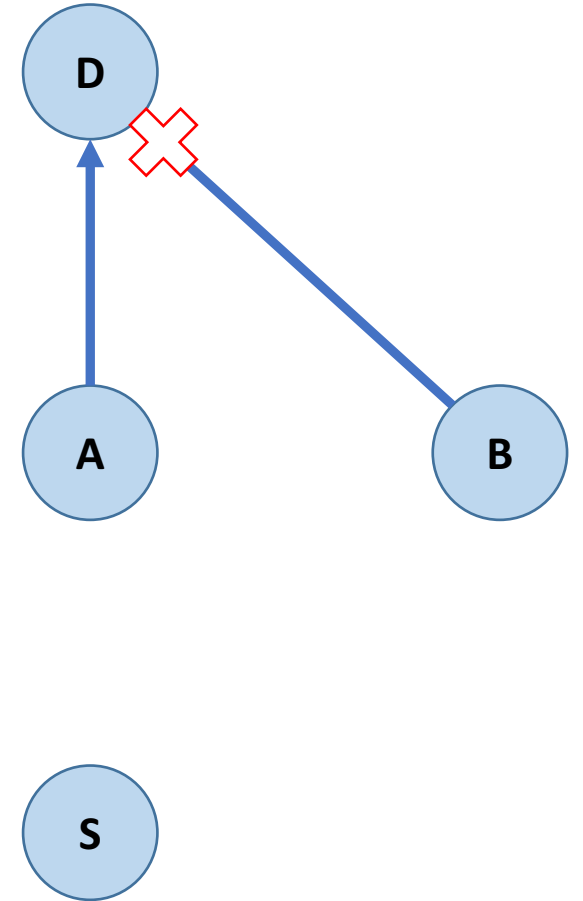
⇒ Data packet is transmitted to both
Default & “Alternate” Parents



Packet Elimination

Elimination :

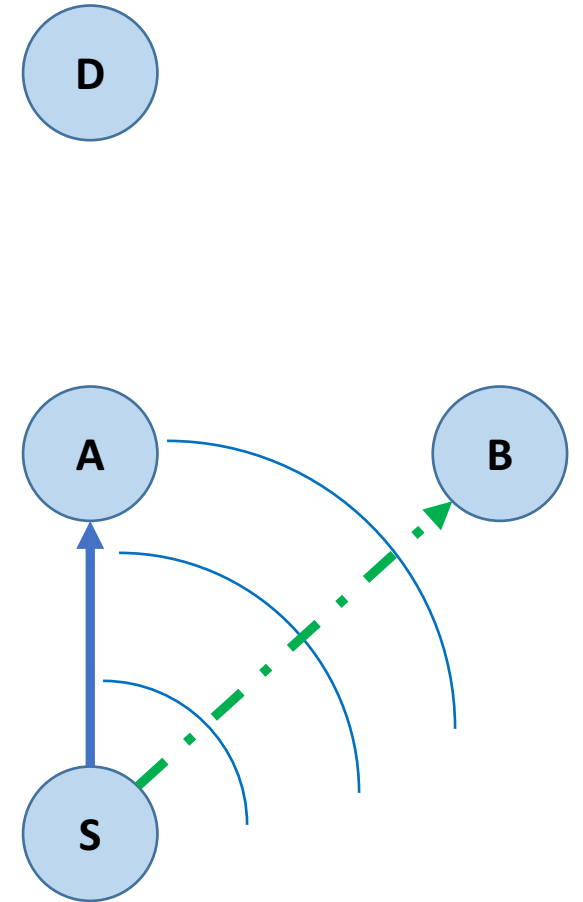
⇒ Discards the copies of a data packet which was previously received.



Promiscuous Overhearing

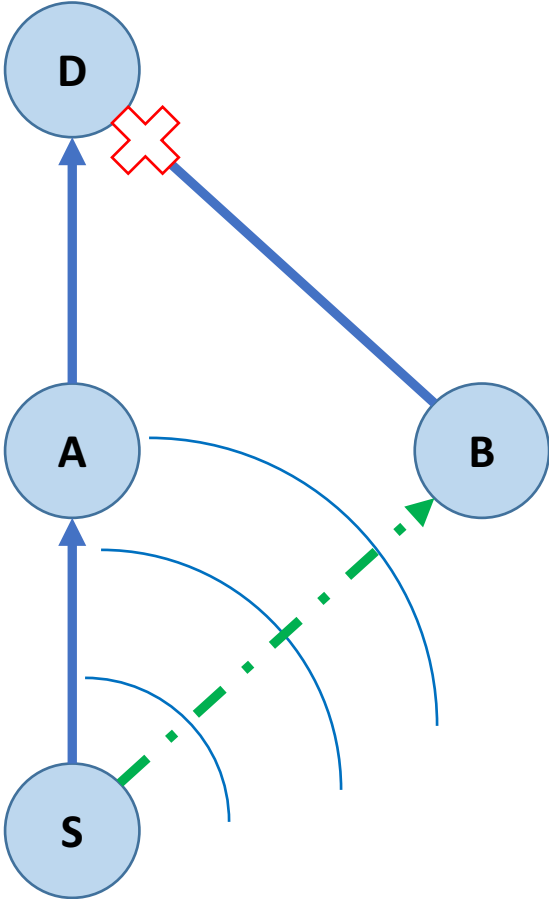
Promiscuous Overhearing :

- ⇒ Wireless medium is broadcast;
- ⇒ Any neighbor of a transmitter may overhear a transmission;
- ⇒ Thus, it increases the probability of the data packet reception at the Destination (D).



IEEE 802.15.4 TSCH Schedule example

| | | | | | | |
|----------------|---|-----------|-------------------|-------------------|-------|-------|
| Channel offset | 3 | | S → A, (B) | | | |
| | 2 | | | | | B → D |
| | 1 | | | S → B, (A) | | |
| | 0 | EB | | | A → D | |
| | | 0 | 1 | 2 | 3 | 4 |
| | | Slotframe | | | | |



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⇒ Alternative Parent Selection modes

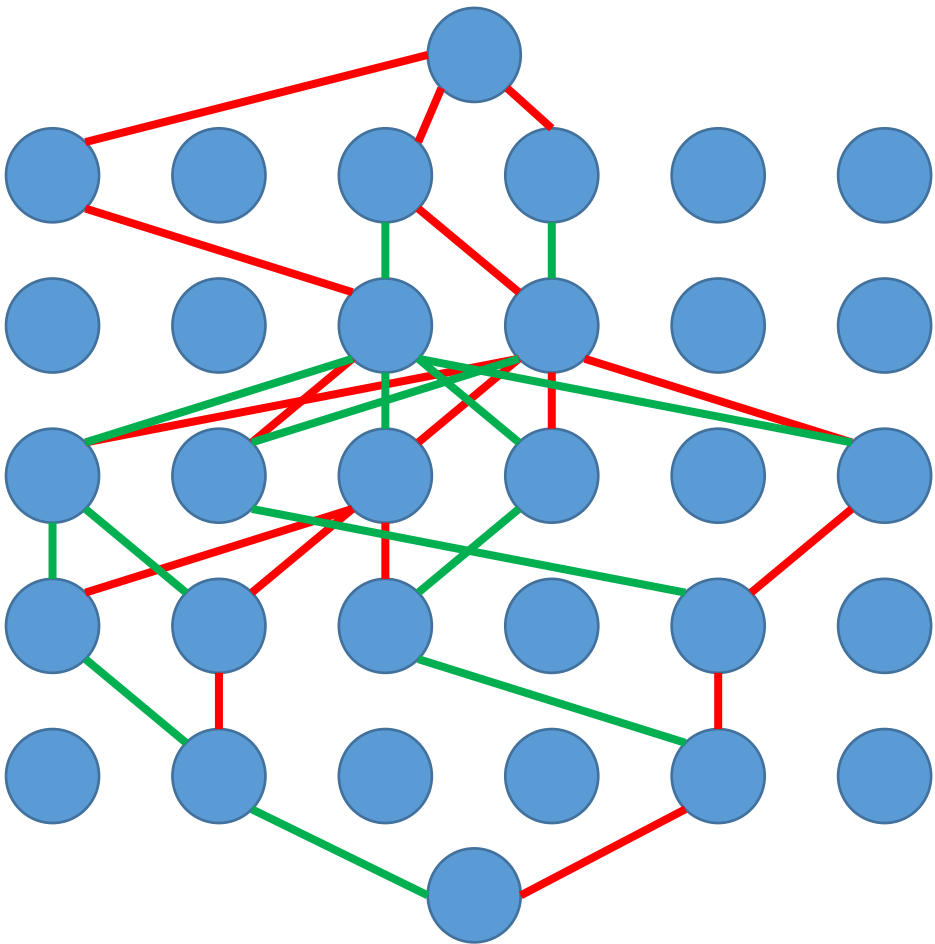
⇒ Recent Results

1. Related to Alternative Parent (AP) Selection

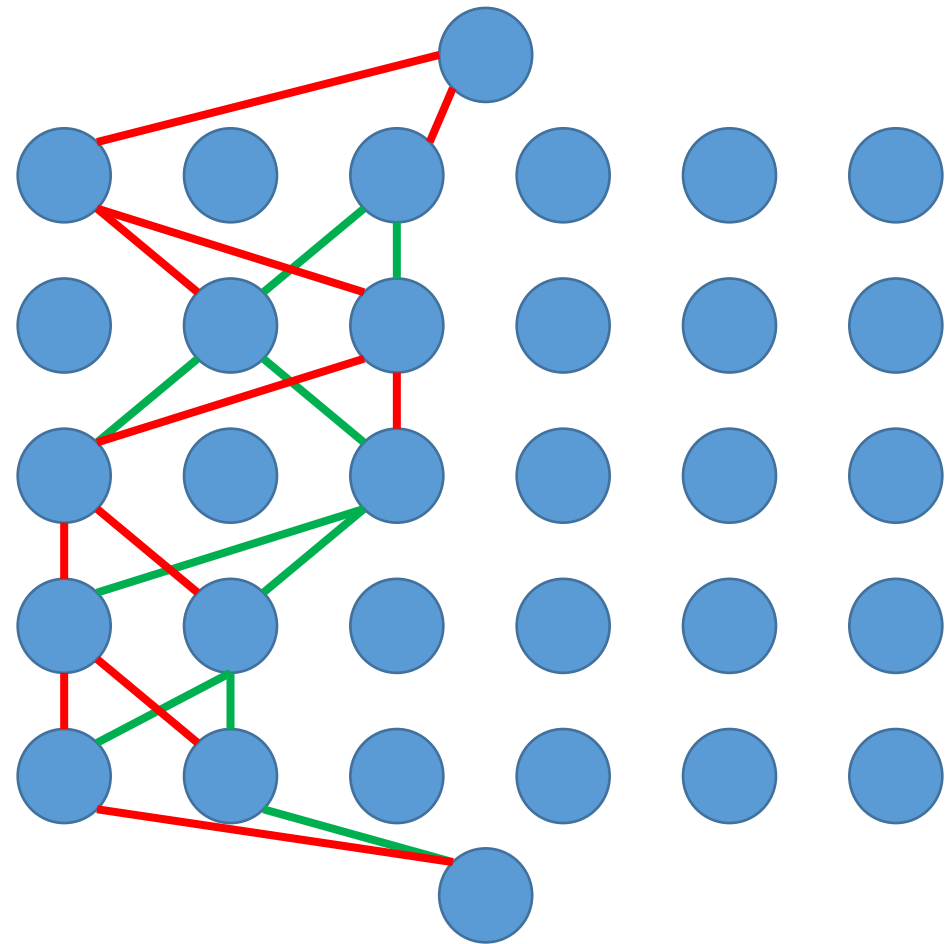
- ⇒ The topology SHOULD be defined when proposing solutions for Alternative Parent Selection.
 - *For instance, the ladder topology should be defined e.g., number of parallel paths, density.*
- ⇒ The routing protocol SHOULD allow for each node to select AP(s) in addition to the DP;
 - *This enables packet replication to multiple parents.*
- ⇒ Control (or mitigate) network flooding by **carefully selecting** the Alternative Parent (**disjoint vs common ancestor pattern**);
 - *Considering that the Packet Replication procedure increases the traffic in a network, when proposing solutions for Alternative Parent Selection, they should be efficient enough to mitigate the uncontrolled packet duplications.*

1. Related to Alternative Parent (AP) Selection

Disjoint



Common Ancestor



2. Related to Propagated Information

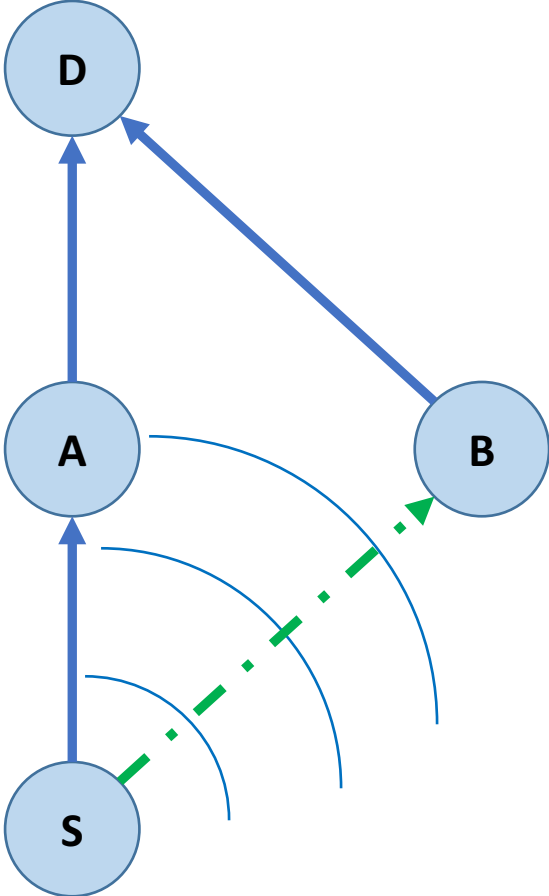
⇒ Nodes **MUST** have a way of receiving the required information for efficient Alternative Parent Selection.

- *As an example, in RPL to achieve the **Common Ancestor Pattern**, it is possible to use and extend the DODAG Information Object (DIO) Control Message to allow nodes to propagate information about their Parent Set to potential children.*

3. Related to Promiscuous Overhearing

⇒ The **MAC implementation** MUST support bypassing MAC address filtering to accept the overheard frame.

| | | | | | | |
|----------------|-----------|----|-------------------|-------------------|-------|-------|
| Channel offset | 3 | | S → A, (B) | | | |
| | 2 | | | | | B → D |
| | 1 | | | S → B, (A) | | |
| | 0 | EB | | | A → D | |
| | 0 | 1 | 2 | 3 | 4 | |
| | Slotframe | | | | | |



4. Related to Packet Elimination

⇒ To perform Packet Elimination the data packet copies MUST be able to identify copies, e.g., sequence number or time stamp.

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⇒ *Alternative Parent Selection modes*

⇒ Recent Results

Alternative Parent Selection

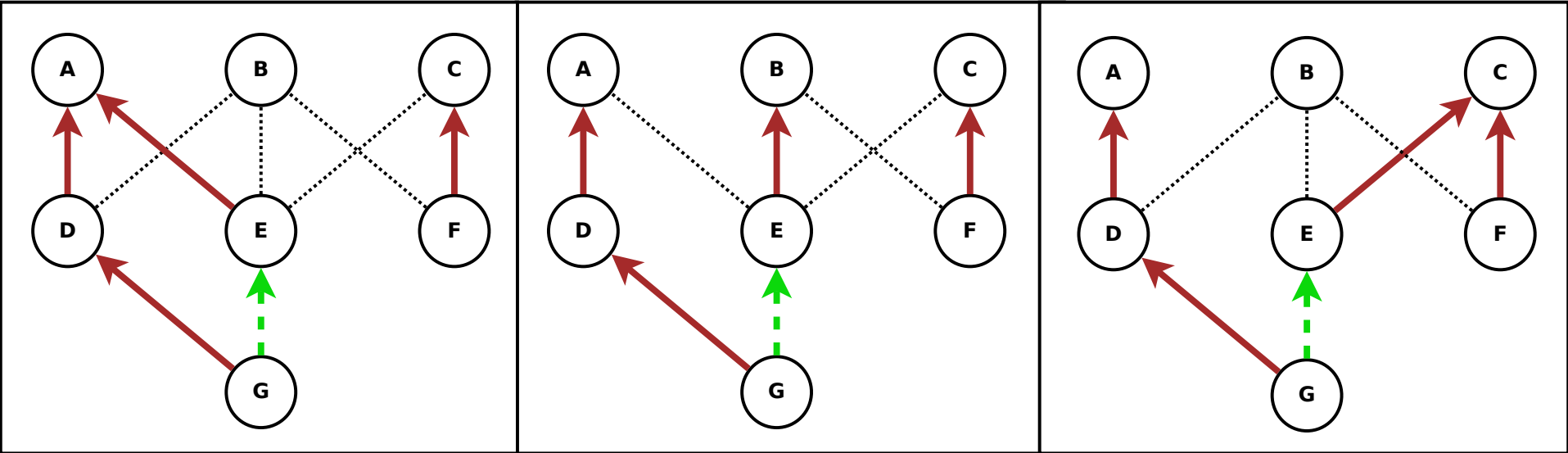
One possible option is to select the Alternative Parent as the one having *common ancestor* with the Default Parent.

Common Ancestor (CA) example modes

Strict CA

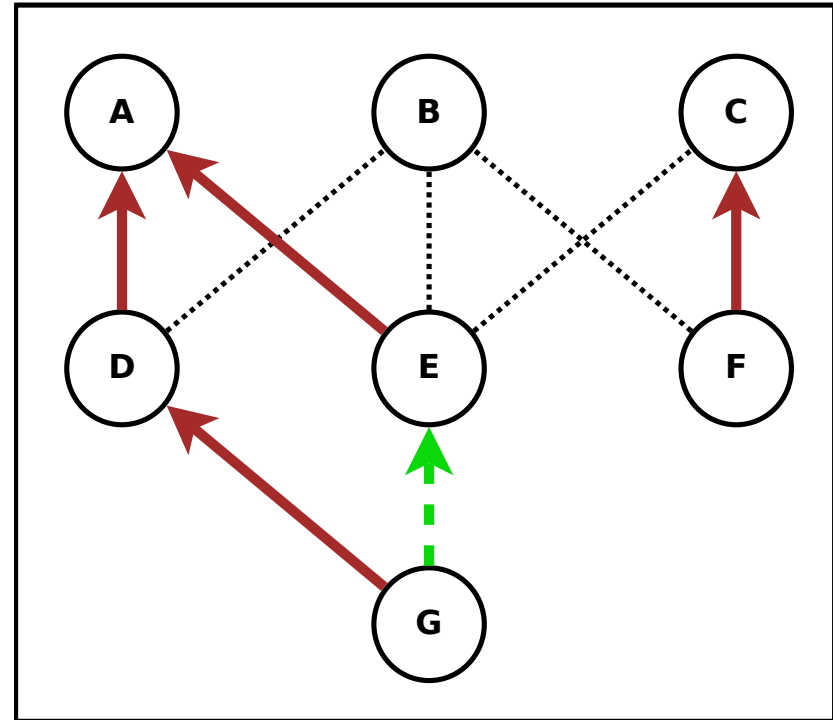
Medium CA

Soft CA



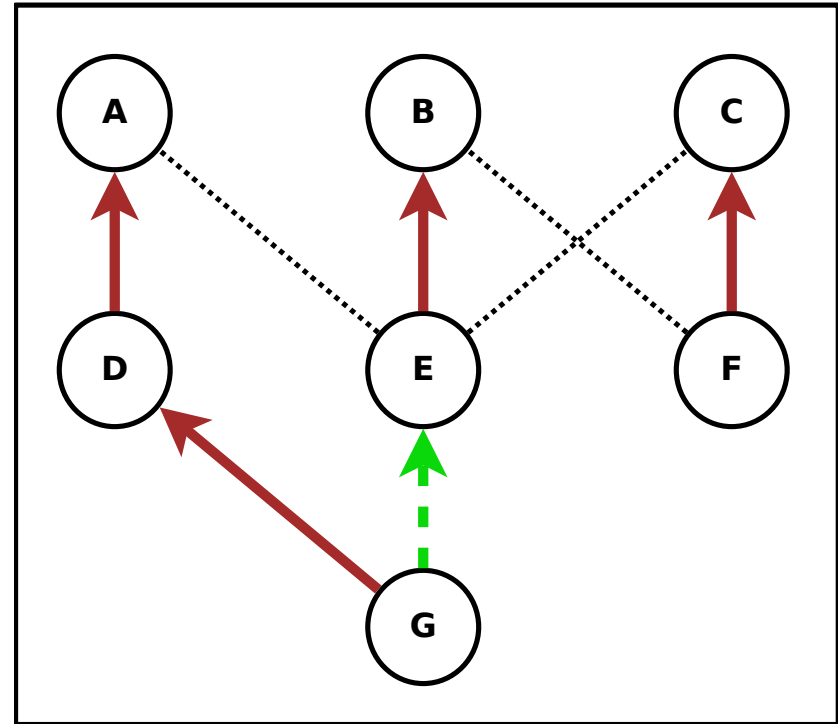
Common Ancestor : **Strict** mode

$$PP(PP) = PP(AP)$$



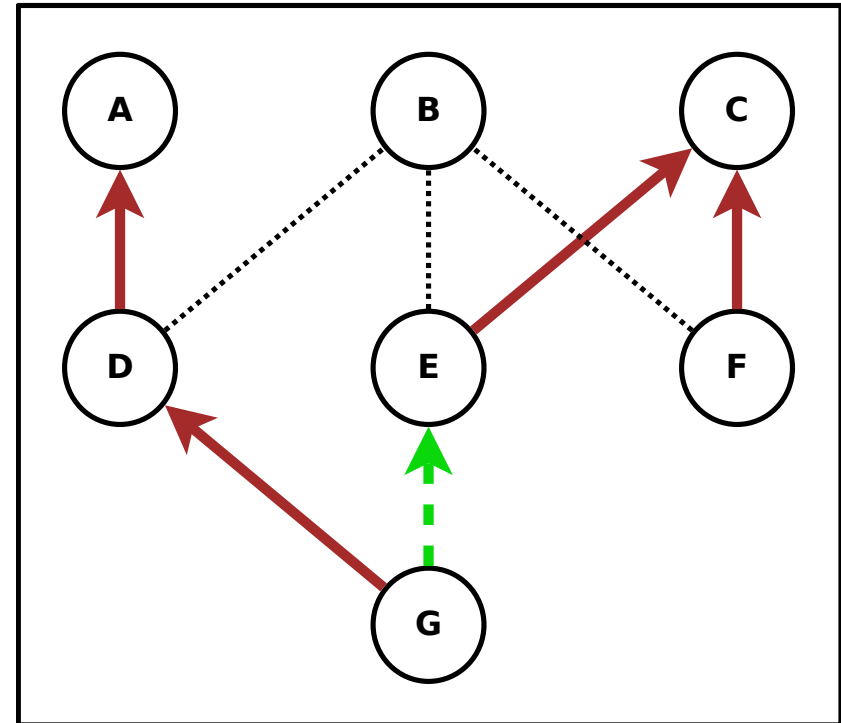
Common Ancestor : **Medium** mode

$$PP(PP) \in PS(AP)$$



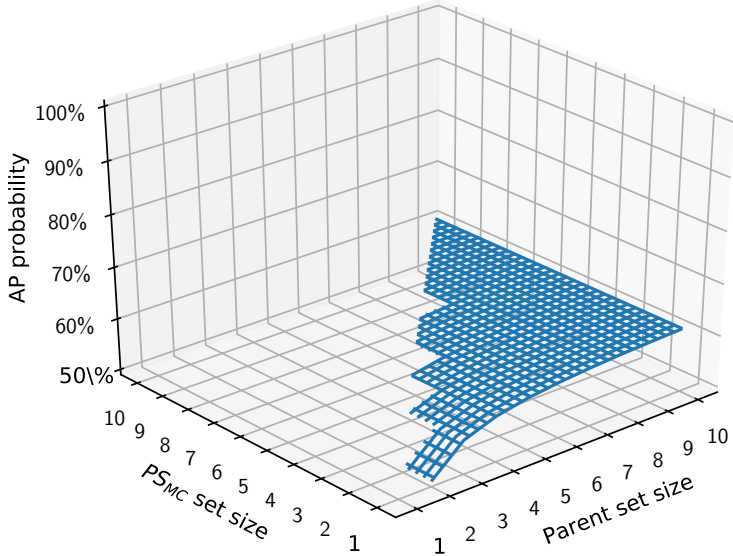
Common Ancestor : **Soft** mode

$$PS(PP) \subseteq PS(AP)$$

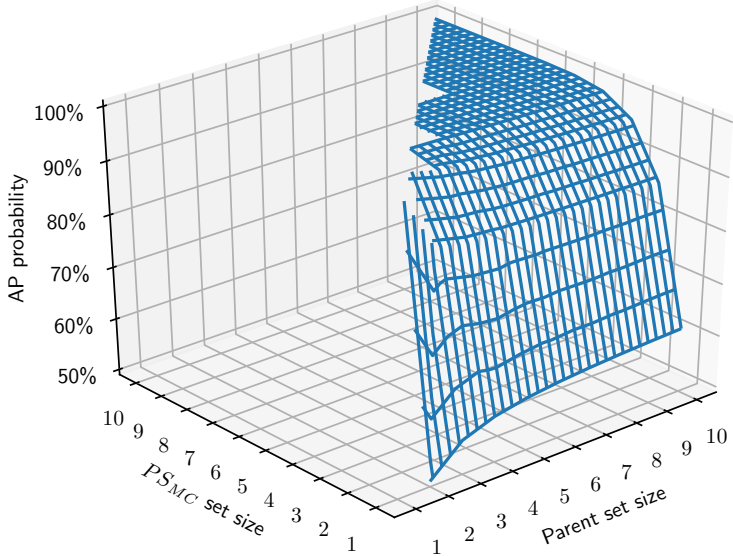


Common Ancestor : Probabilities

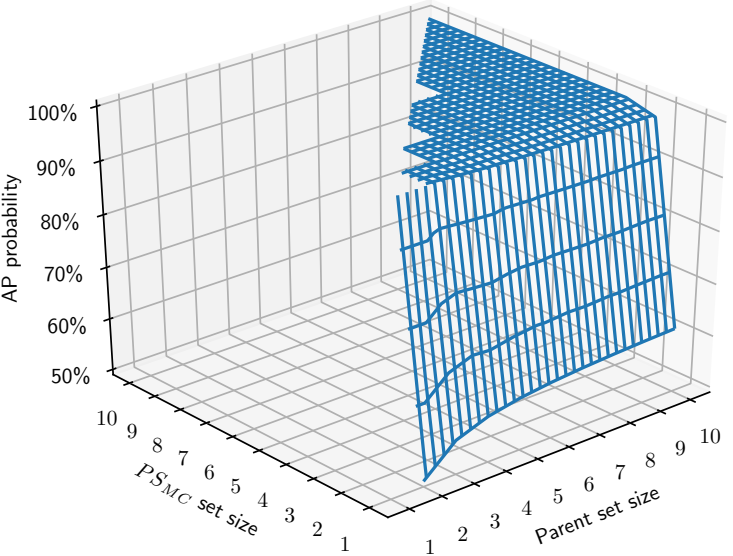
Probability of finding an Alternative Parent



Strict CA



Medium CA



Soft CA

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"Alternative Parent Selection for Multi-Path RPL Networks"

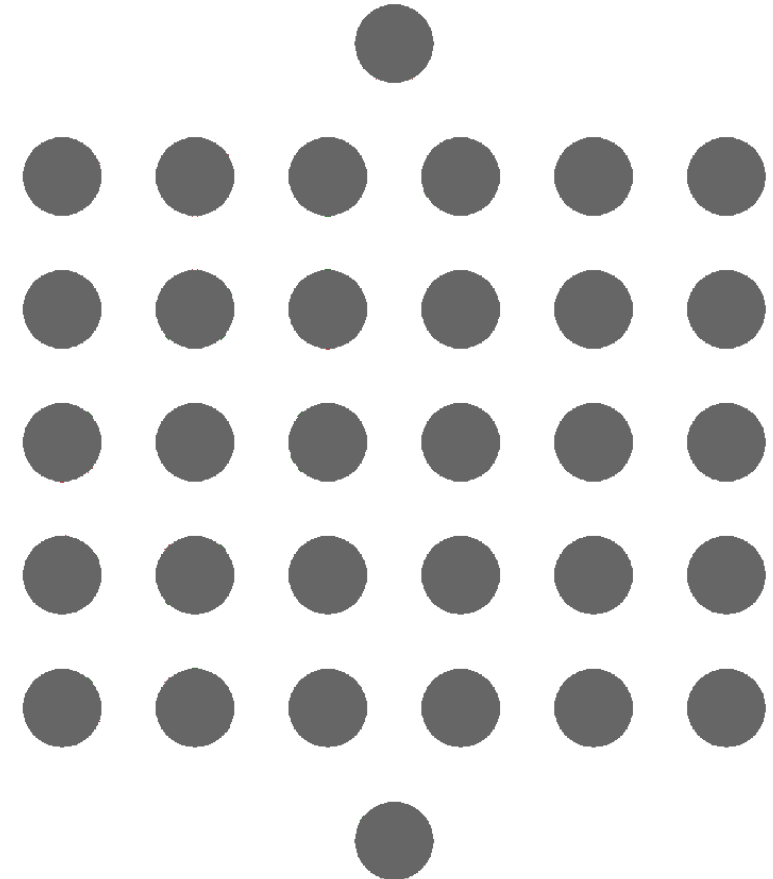
T. L. Jenschke, G. Z. Papadopoulos, R.-A. Koutsiamanis and N. Montavont

In Proc. **IEEE WF-IoT 2019** - Limerick, Ireland, April 2019

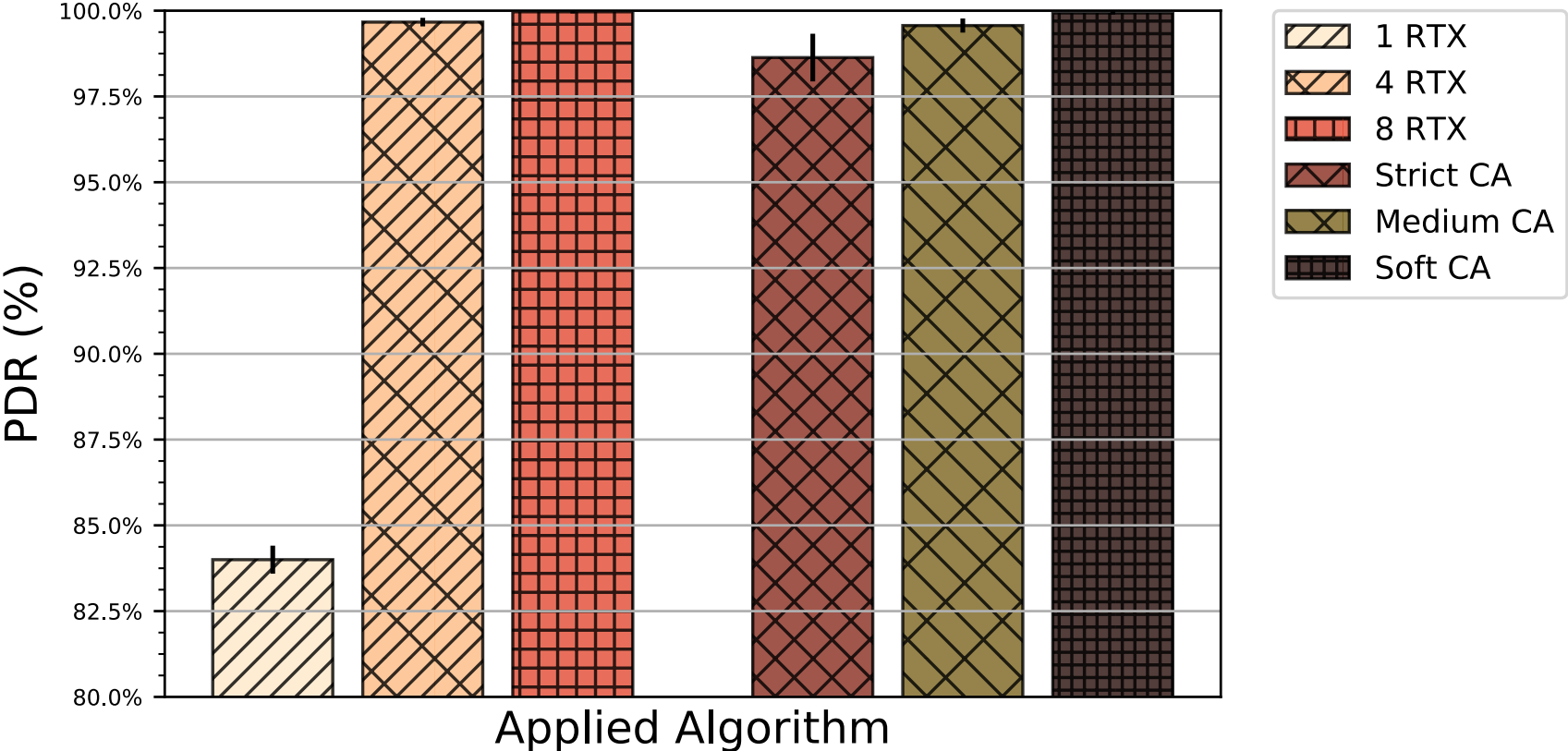
PRE Recent Results

| TSCH | Single- path | Multi-path |
|------------------|---------------------|---------------|
| Scheduling | Centralized | Centralized |
| EB period | 4 sec | 4 sec |
| Timeslot length | 10 ms | 10 ms |
| Slotframe length | 345 Timeslots | 345 Timeslots |
| Nº of channels | 1 | 1 |
| Nº of RTX | 1 RTX, 4 RTX, 8 RTX | 1 RTX |

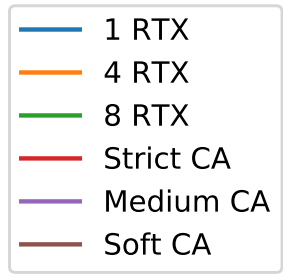
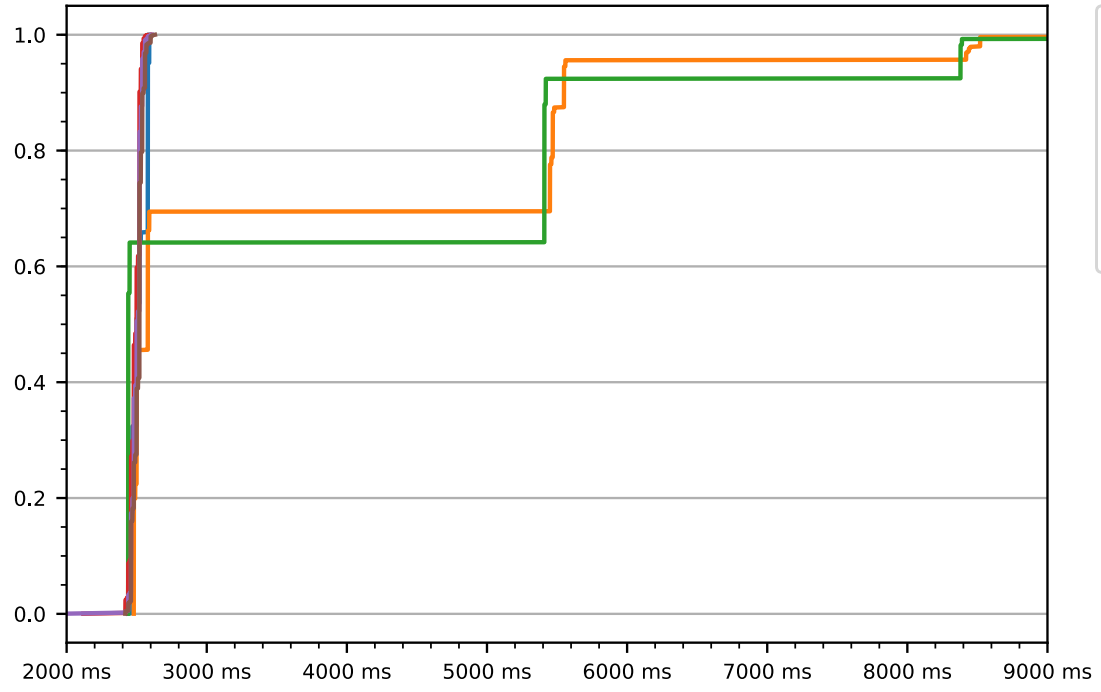
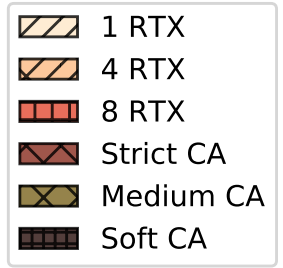
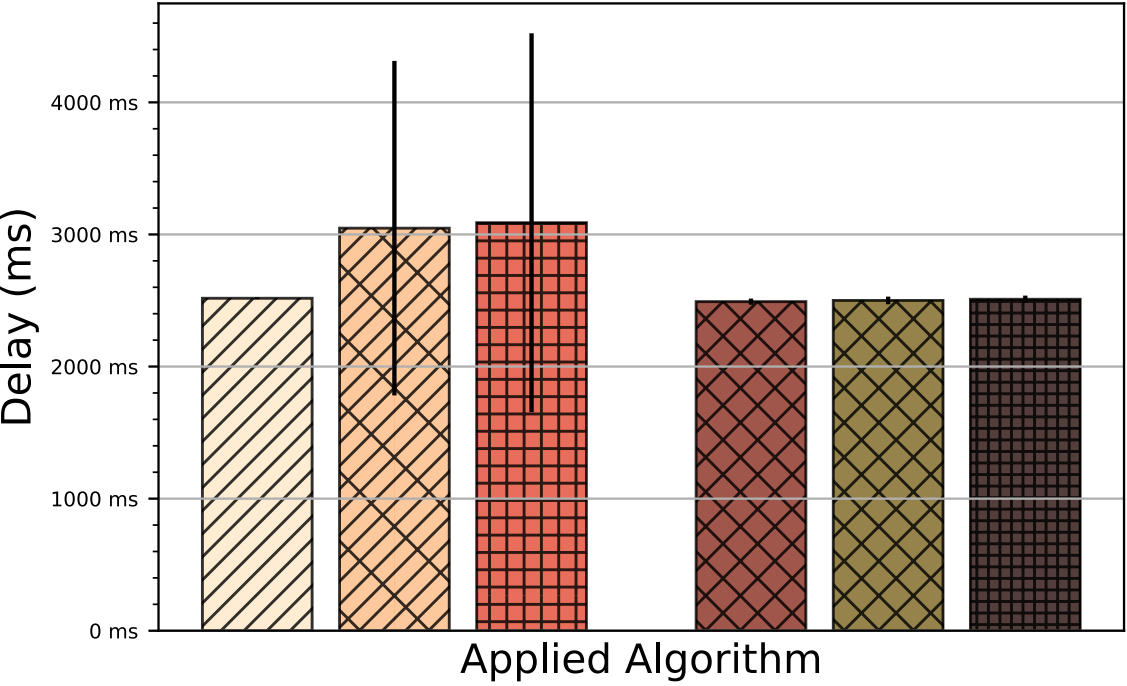
| Simulation | | Topology | |
|--------------------|-----------------|------------------|------------|
| Duration | Until 1000 pkts | Topology | Multi-hop |
| Data traffic | 1 pkt/18 sec | Nº of nodes | 32 |
| Routing | RPL | Nº of layers (L) | 5 |
| Parent set size | 6 | Nº of sources | 1 |
| PS_{MC} size (M) | 3 | Link quality | 70% - 100% |



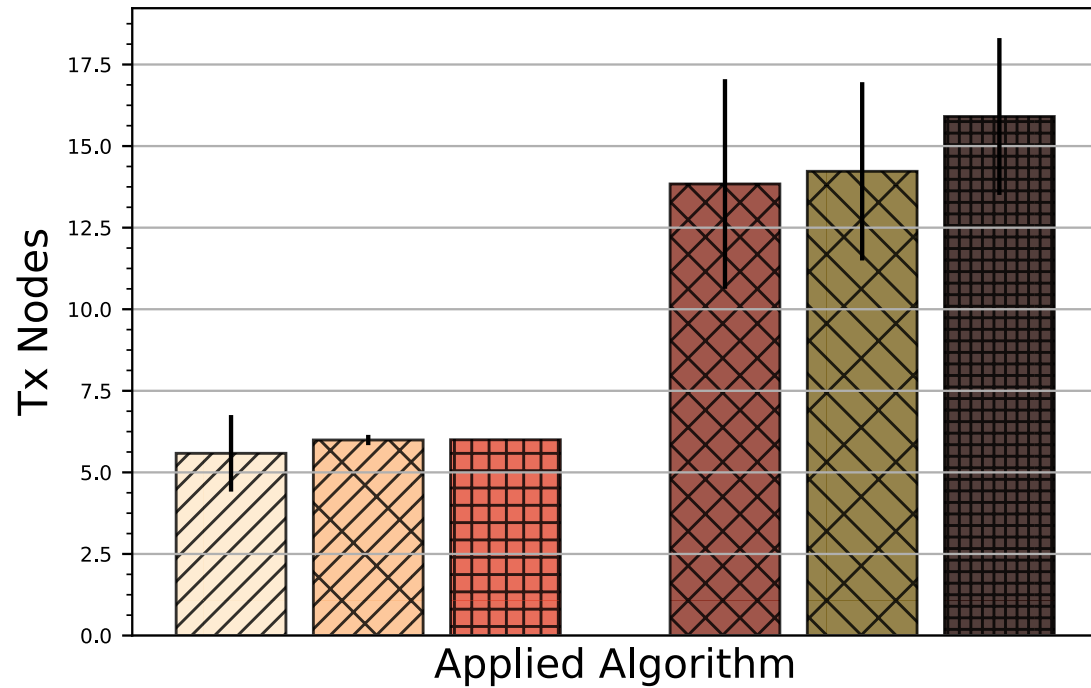
PRE Recent Results : PDR



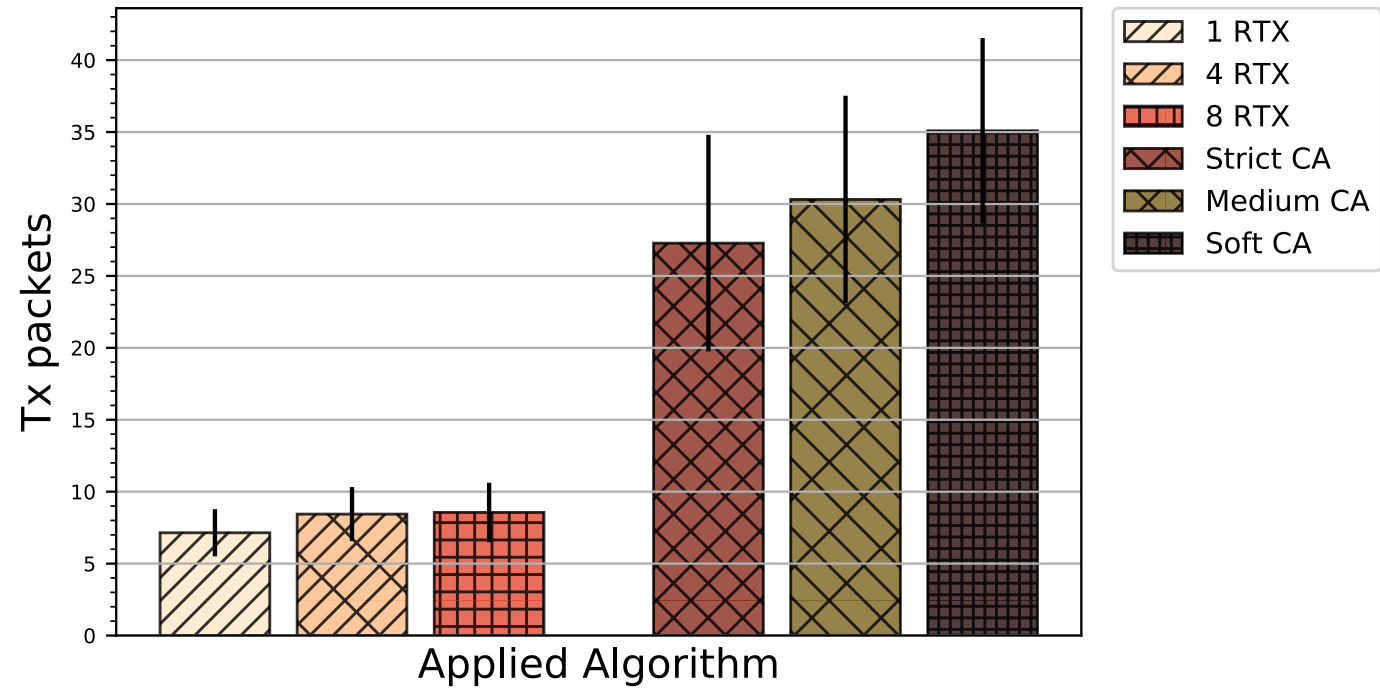
PRE Recent Results : Delay and Jitter



PRE Recent Results : Traversed nodes & TX packets



of traversed nodes



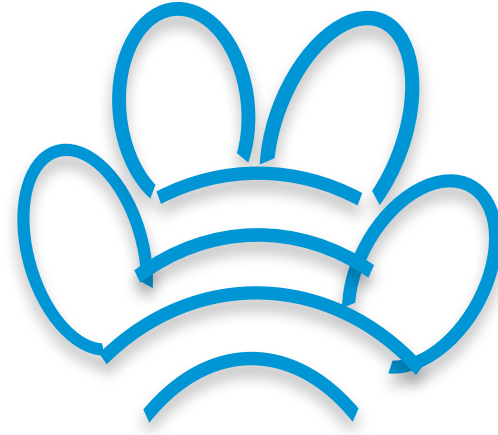
of packet copies per source packet

Implementation Status

⇒ Partial code is available here :

- Contiki : Parent extension (DIO) <https://github.com/ariskou/contiki/tree/draft-koutsiamanis-roll-nsa-extension>
- Wireshark dissectors (for the optional TLV, i.e., PS):
<https://code.wireshark.org/review/gitweb?p=wireshark.git;a=commit;h=e2f6ba229f45d8ccae2a6405e0ef41f1e61da138>

⇒ Shall we push the results to github repository?



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Thanks!

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