Collision Prevention in Distributed 6TiSCH Networks

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Outline

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General introduction

IoT & Wireless Sensor Networks

IoT

- Historically networks were a connection of high performance expensive computers.

Wireless Sensor Networks

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Wireless Sensor Networks

- A source of communication between the IoT nodes.
- Main contributions are : low power, low cost.
- IEEE802.15.4 one of the main standard for those Networks

General intoduction

IEEE802.15.4

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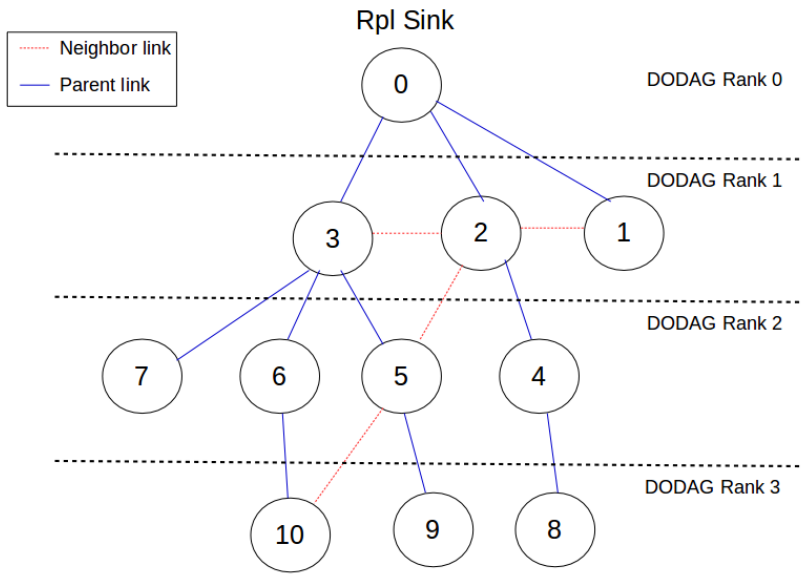
- The low layers of the network (i.e., PHY and MAC)



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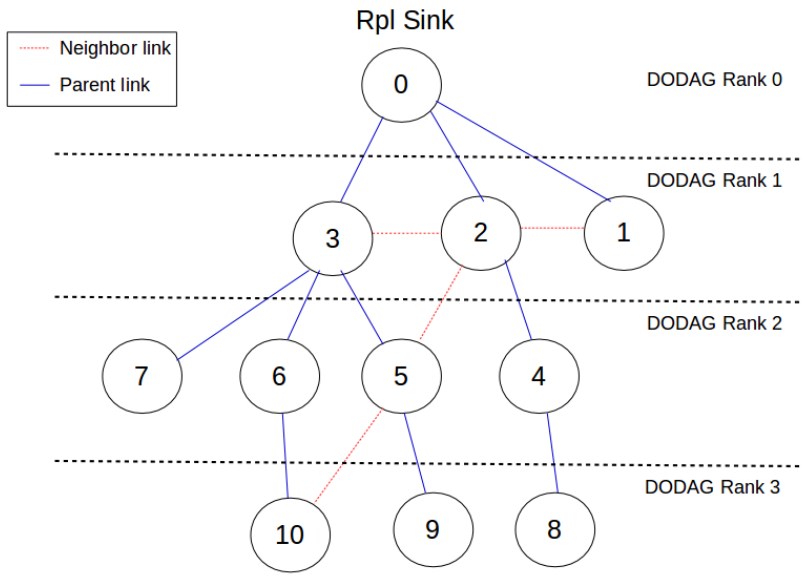

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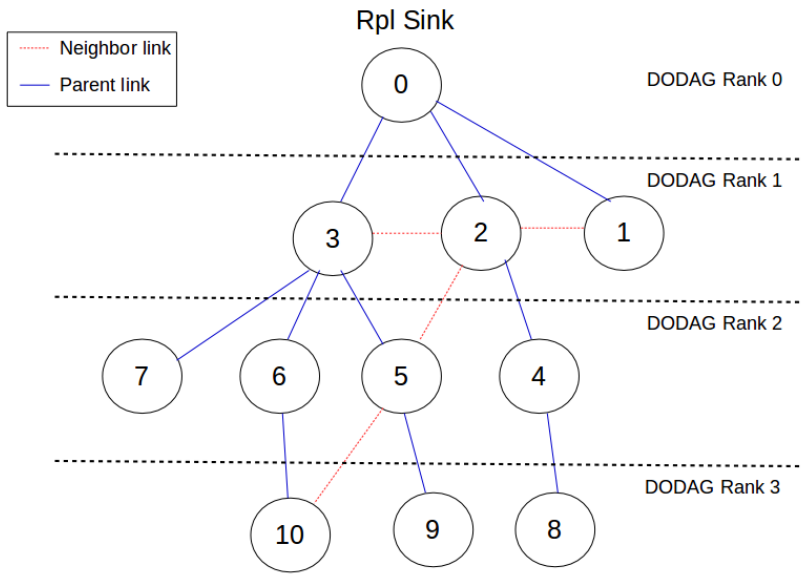

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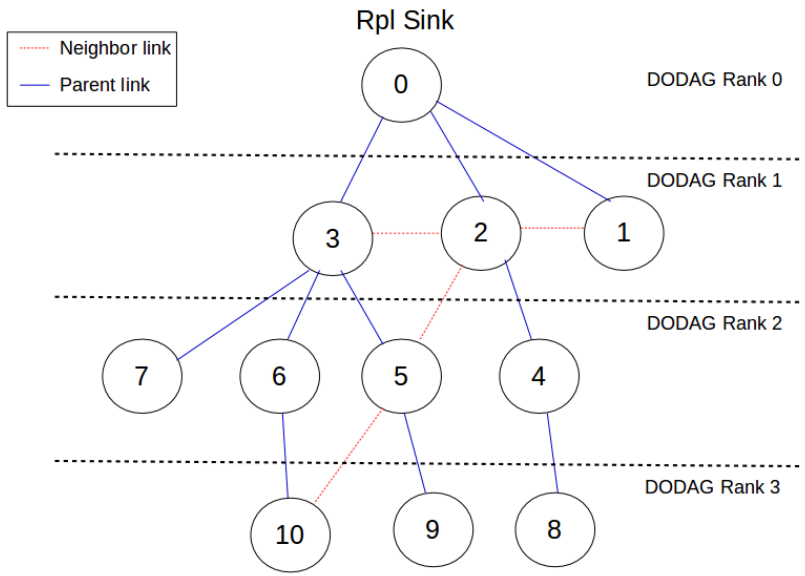

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IEEE802.15.4e TSCH

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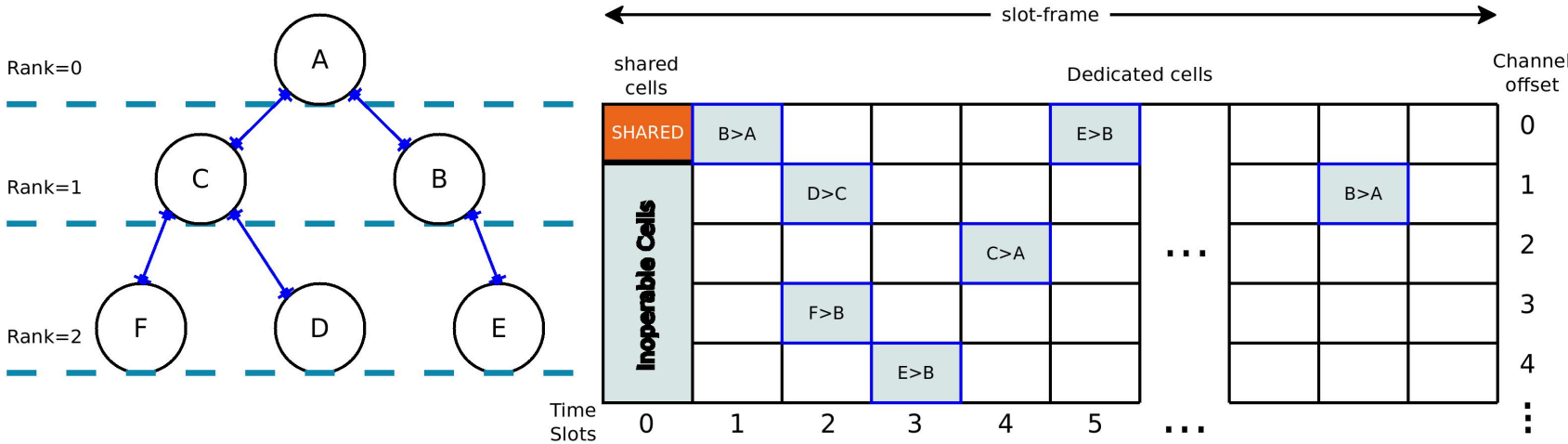

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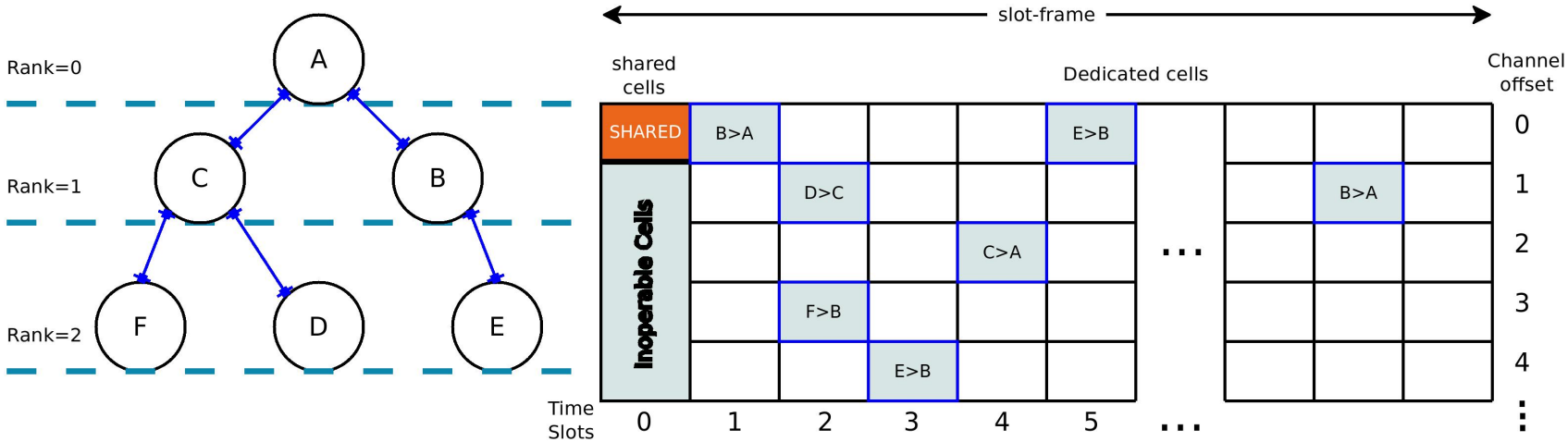
- Extension of the Medium Access Control (MAC) Layer.
- Time-slotted Channel Hopping (TSCH) is based on time frequency multiplexing.



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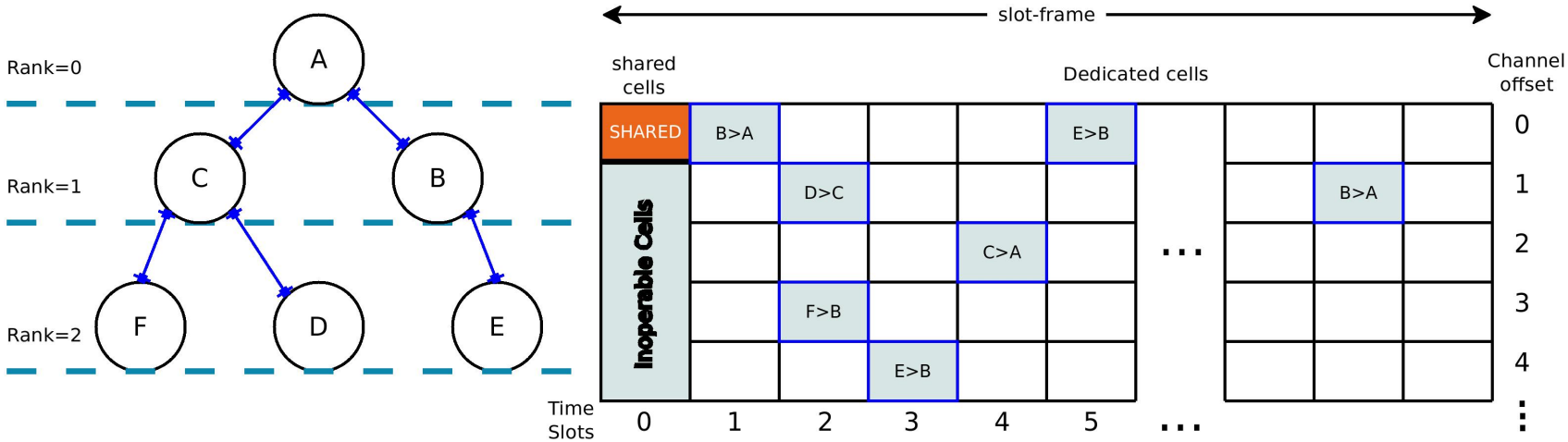

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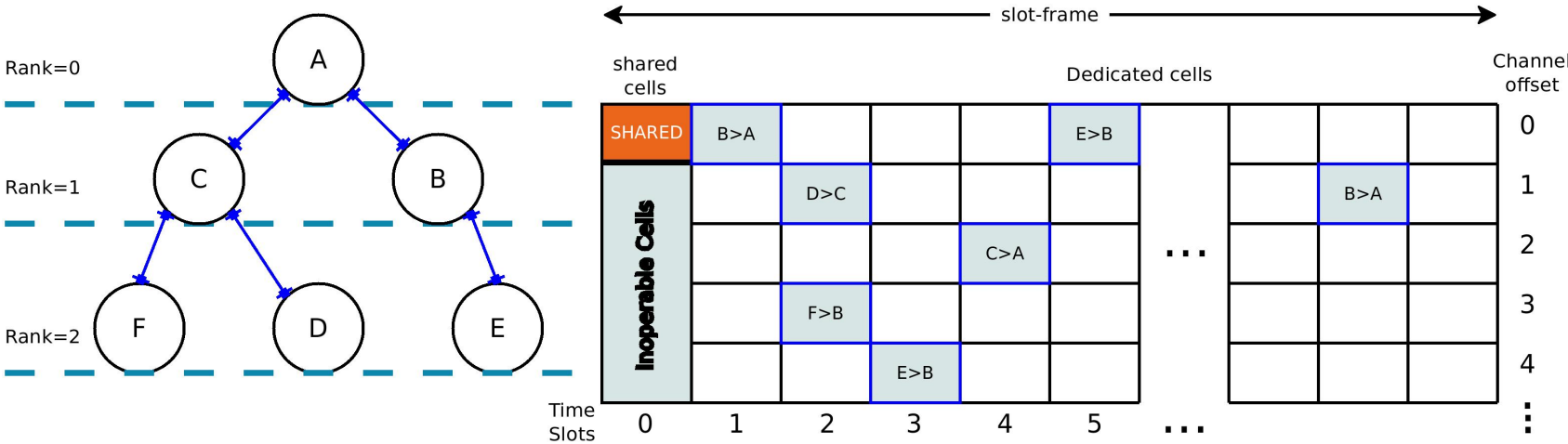

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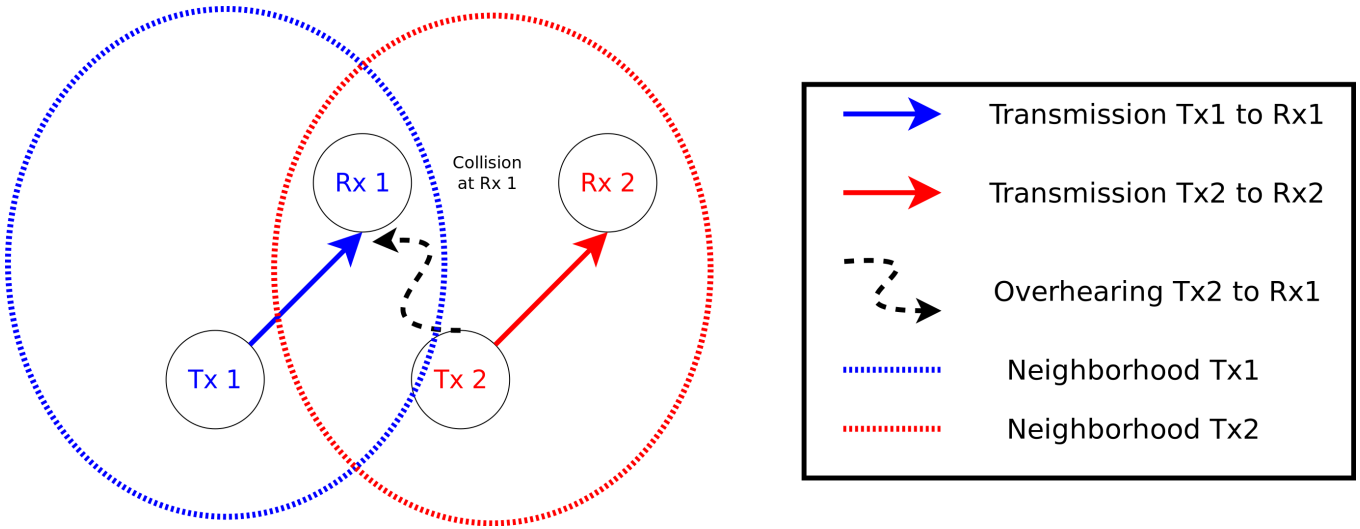

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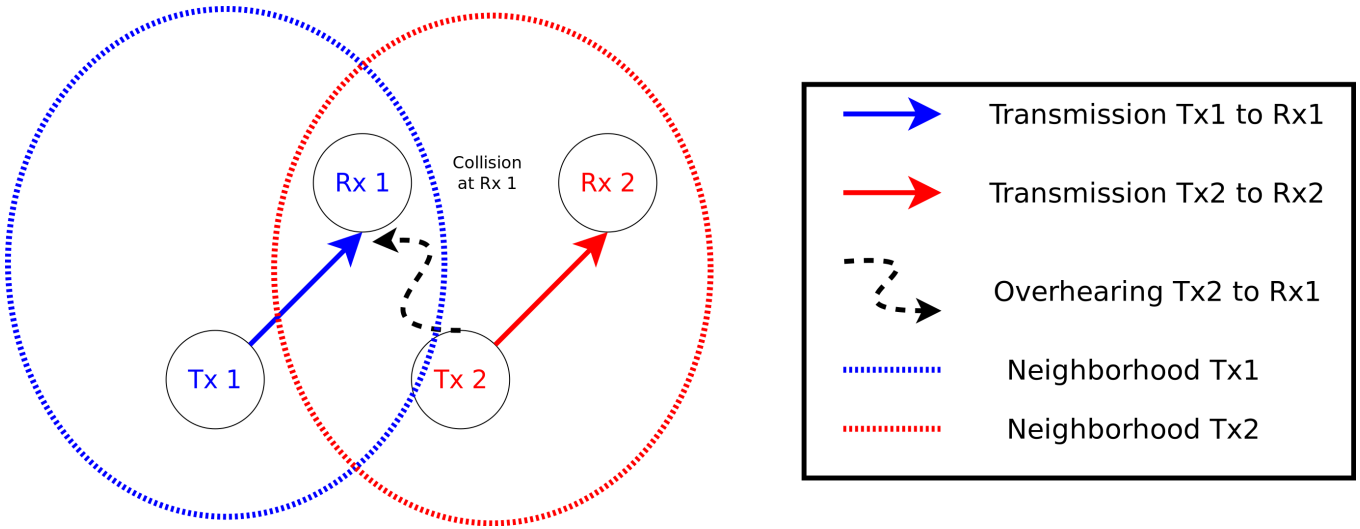

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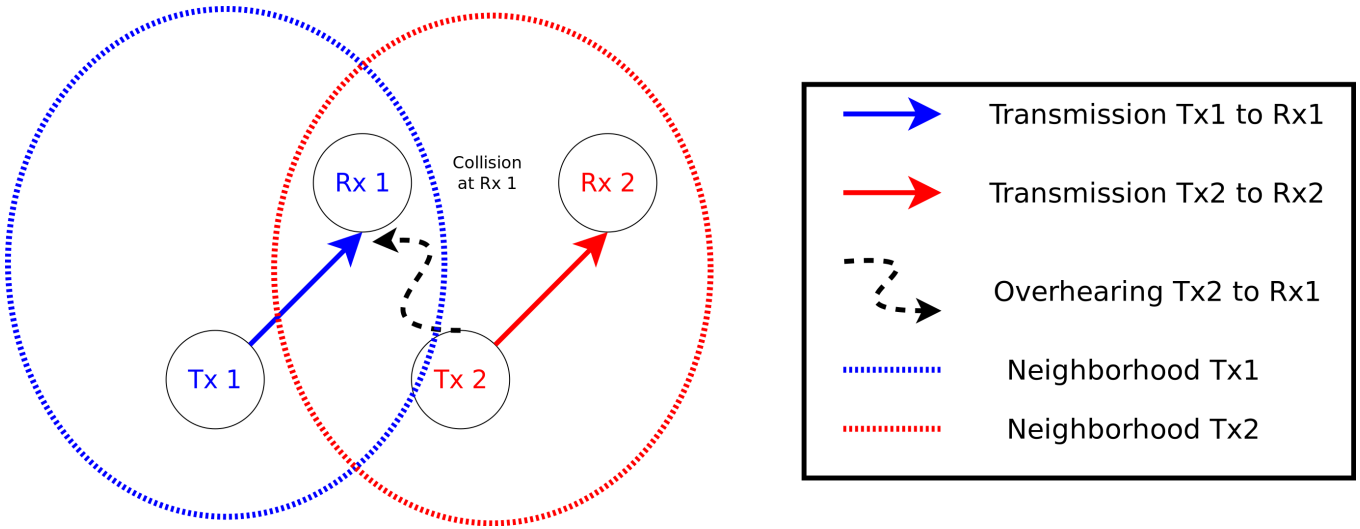

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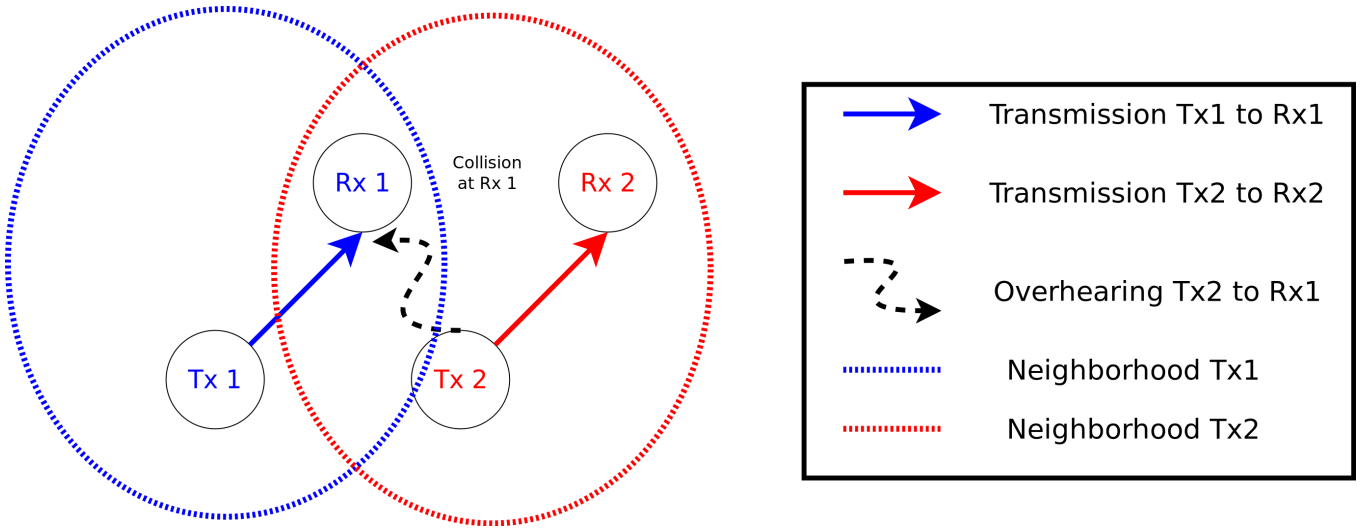
- In the distributed approach Collision.
- Lack of central entity.
- Collision are very expensive in Wireless sensor Networks.



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- Maintaining a good end-to-end communication latency

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IEEE802.15.4e and 6top

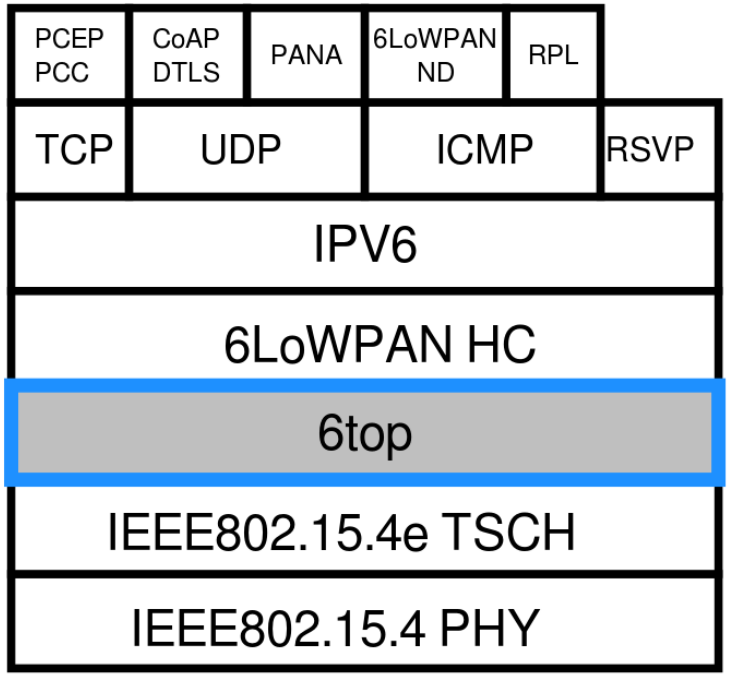
IEEE802.15.4e & 6top

- The standard have defined TSCH schedule but the control of this schedule was left for other protocols for flexibility and optimization.
- 6TiSCH is the merge of IPv6 and TSCH.
- 6TiSCH operation (6top) is a sublayer of 6TiSCH.
- 6top is responsible for the cell addition and deletion.

IEEE802.15.4e and 6top

6top

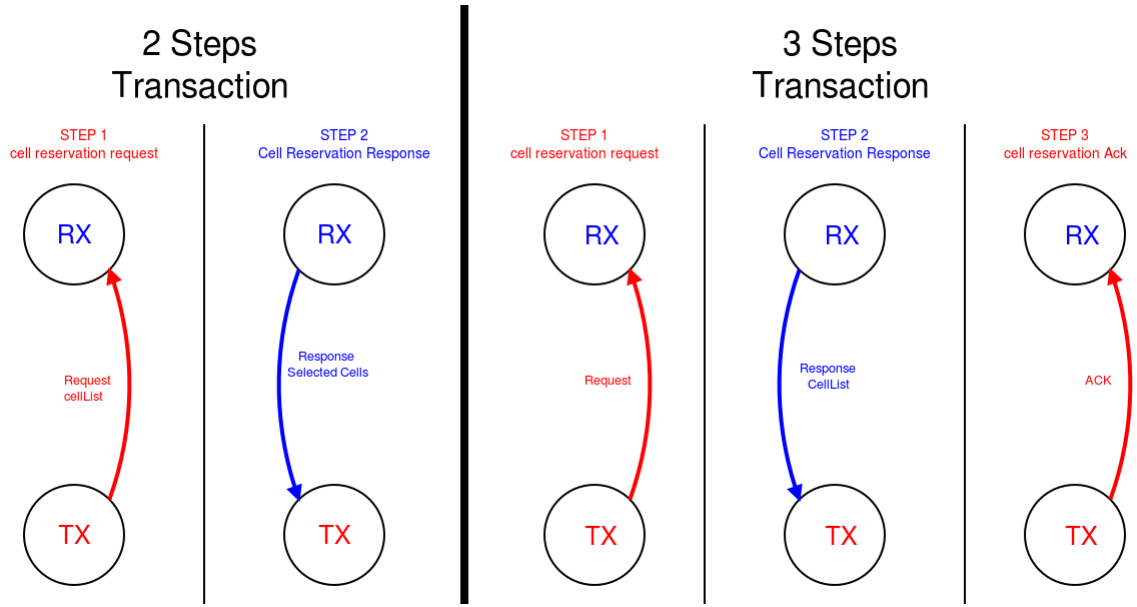
- orchestrates all communications using the TSCH schedule.
- allows the nodes to request for new TSCH cells and update the TSCH schedule table accordingly.
- 6top enables the distributed scheduling in 6TiSCH network.



IEEE802.15.4e and 6top

IEEE802.15.4e & 6top

- 6top transaction assign cells to communicating nodes .
- The scheduling function in 6top will choose the cells randomly from TSCH table.
- The transaction is done in the shared slot.
- The transaction will be received by the neighbor nodes by dropped due too MAC filtering of the messages.



Outline

6top and Collisions

6top

- Nodes have no information about the neighbors.
- 6top will select cells randomly form the TSCH schedule.
- If another neighbor node is using the same cell a collision will occur.
- Collisions are expensive.

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Proposed Mechanism Criteria

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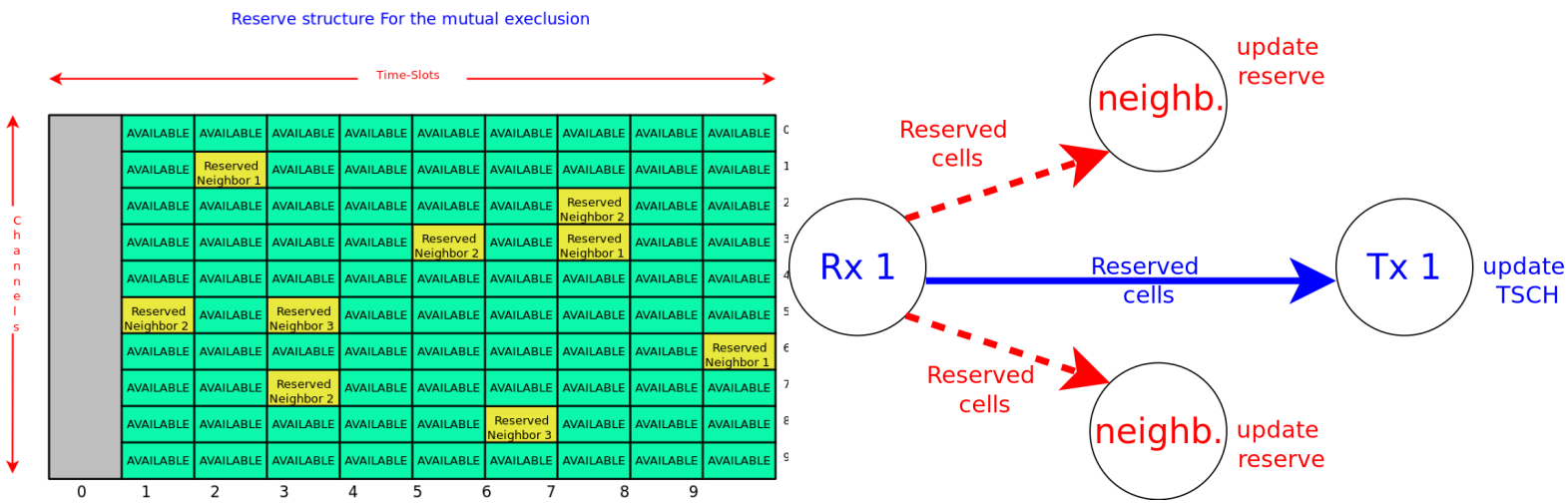
Reserve Table

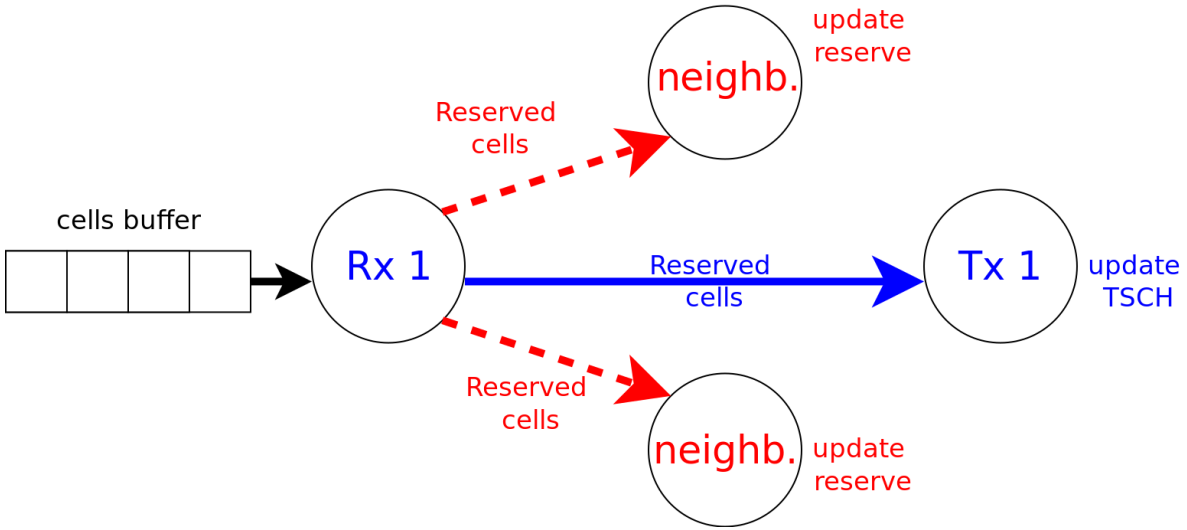
- The nodes will recieve the 6top transaction from the neighbor nodes.
- The cells reserved by neighbors will be reserved by a structure similar to TSCH table.
- Scheduling function will avoid selecting cells found in this structure.
- 6top will control this table so any scheduling function can be used with our implementation.



Outline

Cell Buffer

- The assumption of 100% successful dilevery is not realistic.
- The 6top Transaction maybe lost due too environment effects.
- The loss of the transaction increase the probability of collisions.
- By saving the reserved cells in a buffer, and sending the history of reserved cells this probability can be reduced.



Cell Buffer

- We have created a probablistic model to calaculate the optimal length of the buffer.
- p is the probability of successful transmission.
- we are confidence with a probability P_o that one of the transmission is successful.
- k is the number of retransmission (the optimal length of the buffer).
- we end up with the following equation using binomial distribution:

$$\left\lceil \frac{\log(1 - P_0)}{\log(1 - p)} \right\rceil$$

- According to this equation, and by taking the worst case scenario a buffer of length 10 can assure us 95% of success

Outline

Mechanisim and Results

Methodology

- We used the 6TiSCH simulator ▸ Link, the work of watteyne et al. After implementing our approach and fixing some problems in the simultor to make it more realistic.
- Simulations over 100 nodes, over 100 run on the same topology to assure fairness.
- We have tried different types of topologies, and had the same results for all of them.
- The simulator updates are in my ▸ GitHub, Results and documentation are in my ▸ WIKI PAGE along with my reports and daily progress.

Results

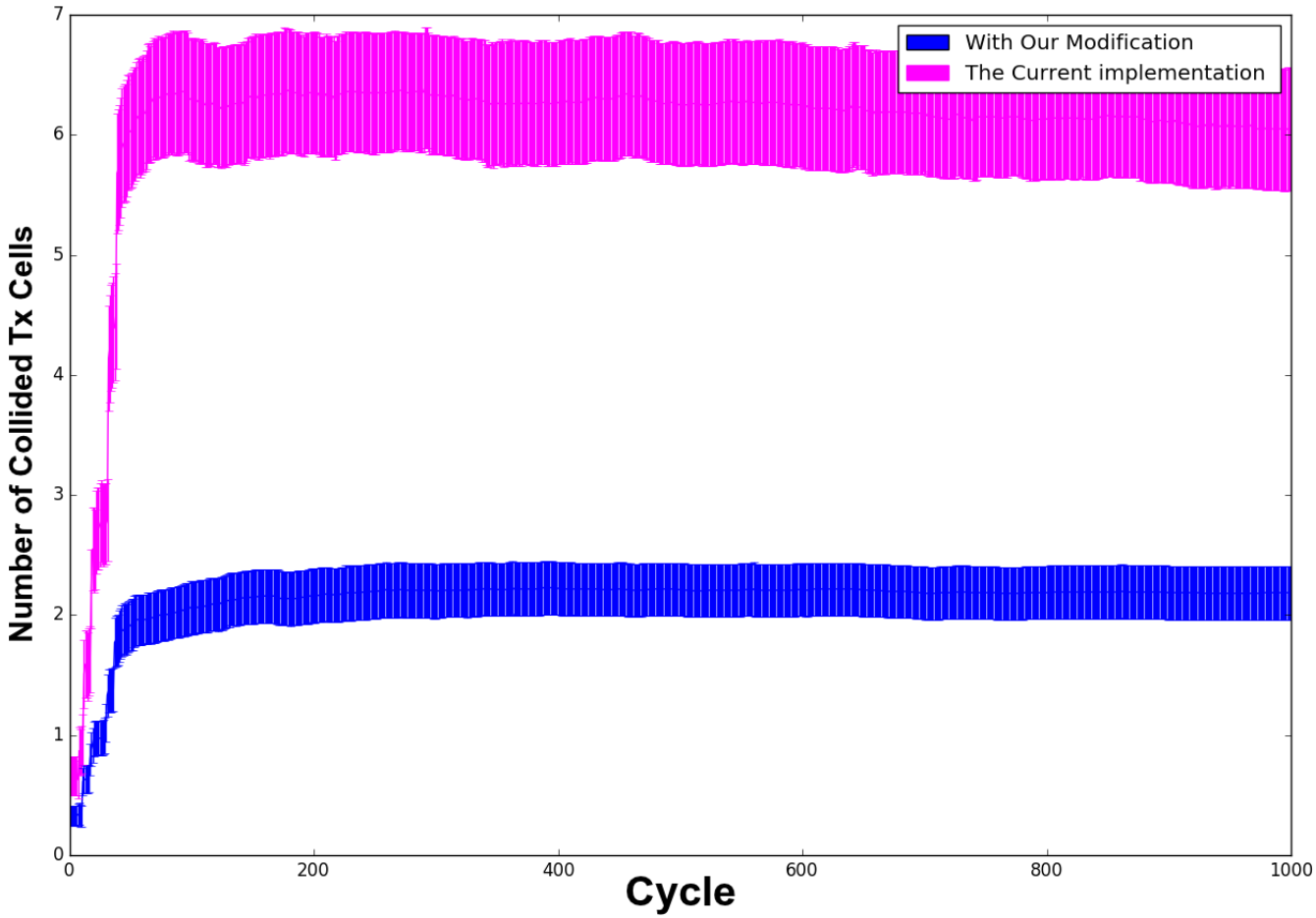


Figure: Simulation of the Number of Collided Txs Cells as Function of Cycle Number (Time)

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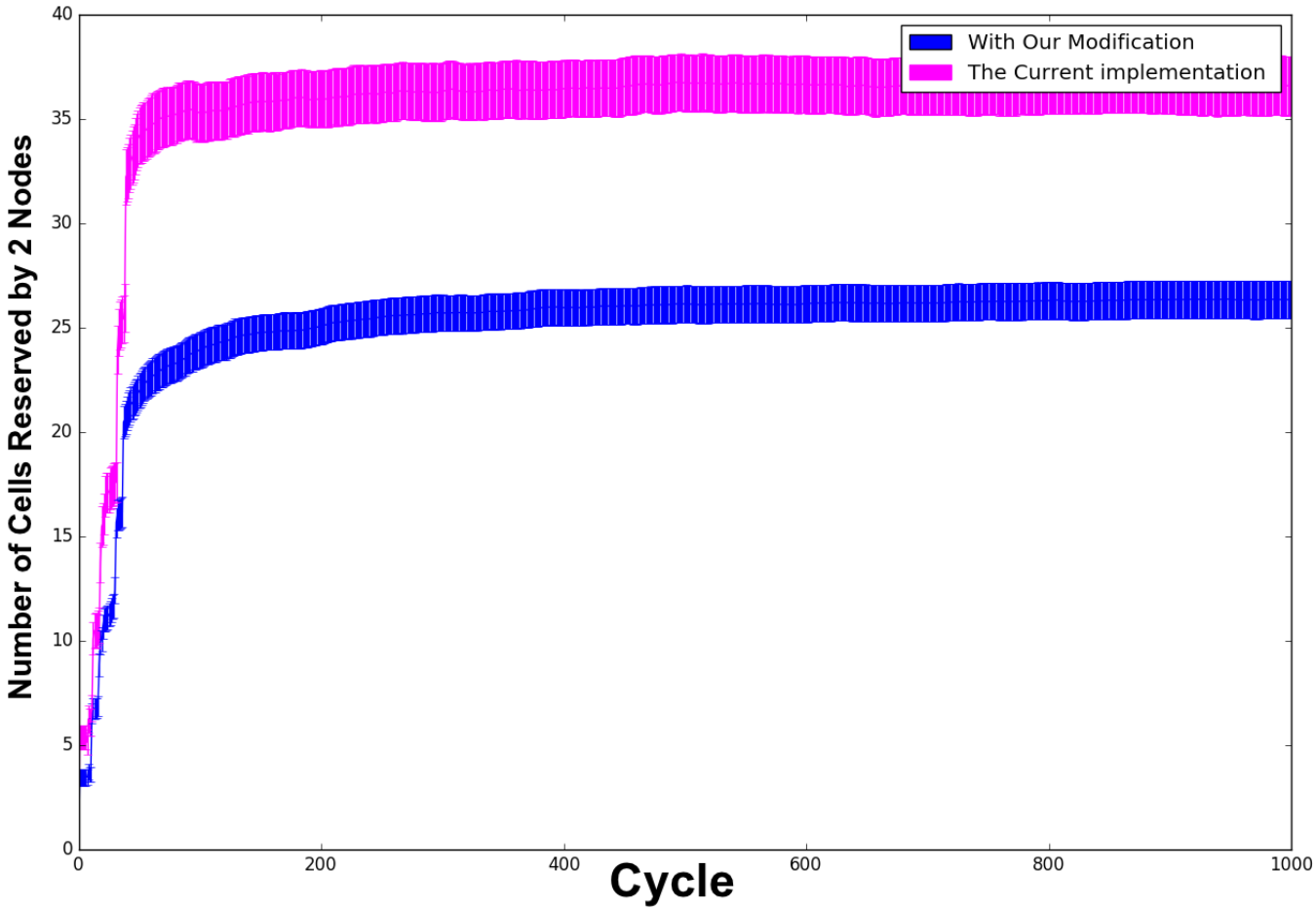

Figure: Simulation of the Number of Cells Reserved by 2 Nodes as Function of Cycle Number (Time)

Related Work Results comparison

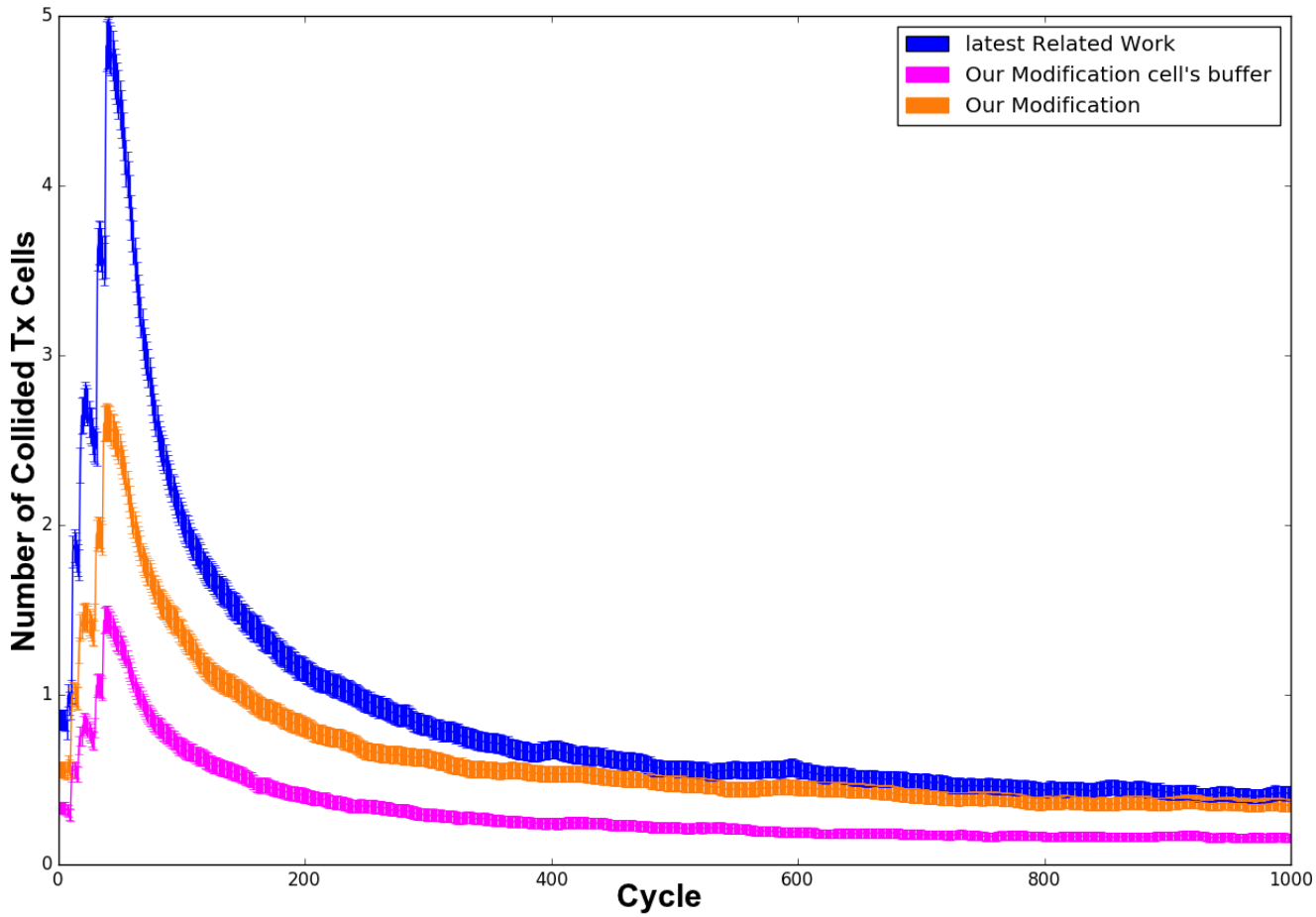

Figure: Simulation of the Number of Collided Txs Cells as Function of Cycle Number (Time) - comparison with the housekeeping approach

Summary

- Our implementation introduce no overhead in the network.
- The implementation achieved 60% reduction in the number of collided Tx cells.
- The implementation have a positive side effect which is reducing the interference in the network .
- Outlook
  - Our goal is to reach a place were we have collision free network, using more complex method.
  - Our prespective in this project was work on 6top, but our next steps is to work on the scheduling function to elimante collision.

For Further Reading I

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