# Collision Prevention in Distributed 6TiSCH Networks

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# Outline

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# General intoduction

## IoT & Wireless Sensor Networks

### IoT

- Historically Network was a connection of high performance expensive Computers.
- Nowadays Network is a connection of entities with limited processing capabilities called Things.
- led us to the idea of *Intenet of Things (IoT)*

### Wireless Sensor Networks

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

# General intoduction

## IEEE802.15.4

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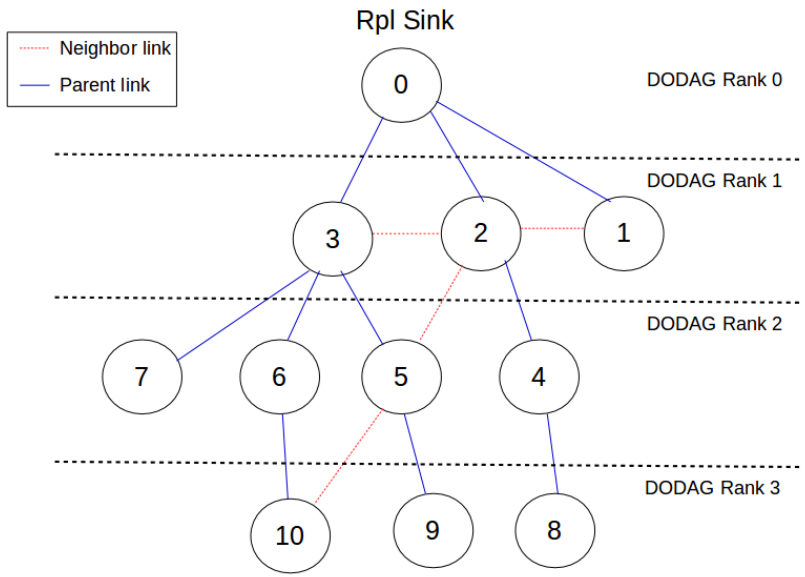
- It defines the low layers of the network (i.e., PHY and MAC)
- Uses RPL routing protocl to create a DODAG graph between the node.
- The communication is one-directional between Rx node (Parent), and Tx node (Child).

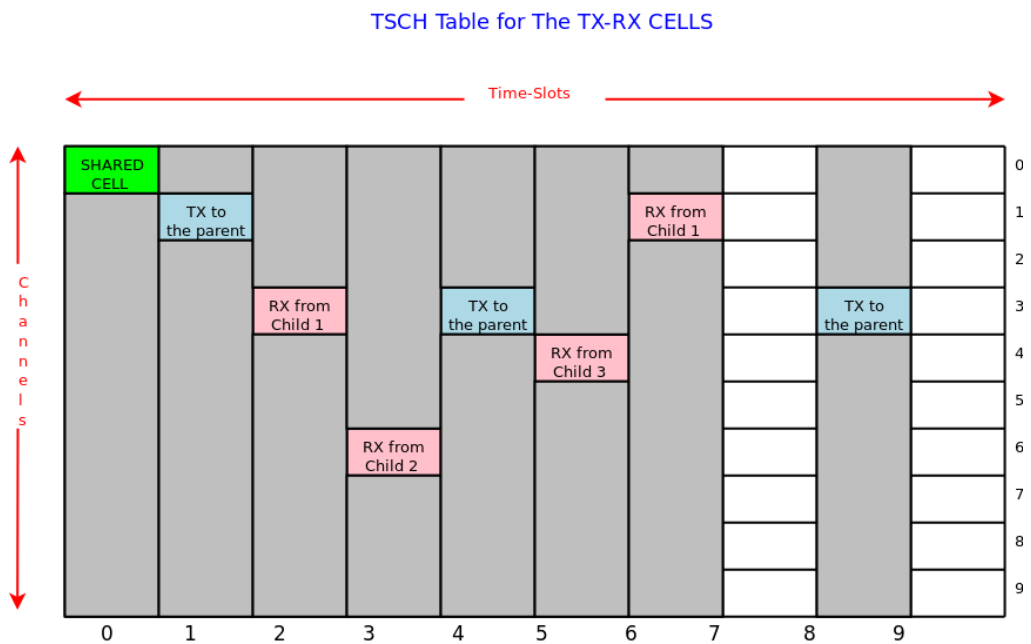


# General intoduction

## IEEE802.15.4

### IEEE802.15.4e TSCH

- The Meduim Access Control (MAC) Layer.
- Based on Time-slotted Channel Hopping (TSCH).
- Two types of cells: dedicated and shared.
- This table can be managed in centrlized or distributed way.

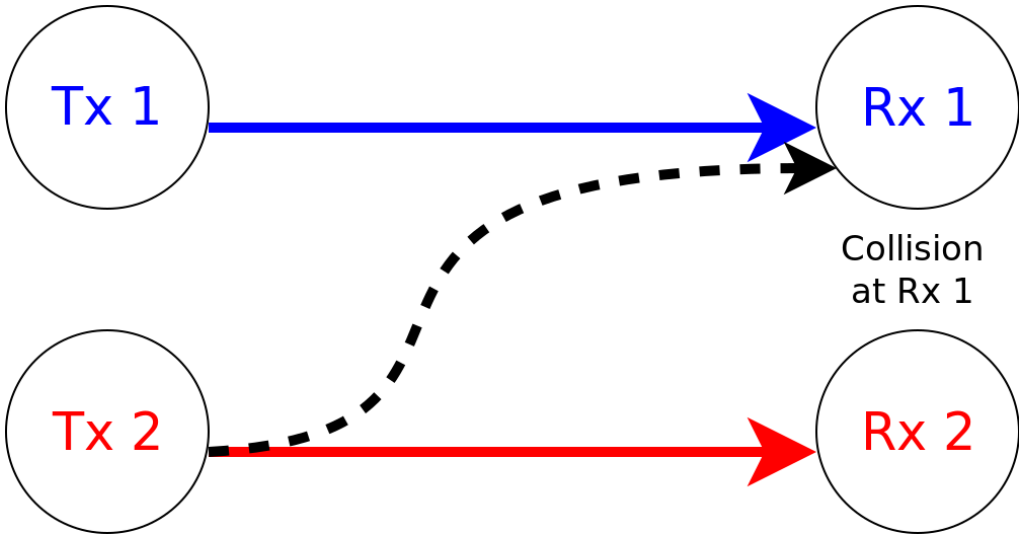


# General intoduction

## Collision in the Dedicated Cells

### IEEE802.15.4e TSCH

- The dedicated cells are supposed to be collision free.
- In the distributed approach.Collision occurs in case neighboring nodes select the same TSCH cell.
- Collision are very expensive in the Wireless sensor Networks.



# Outline

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- Modifying the Cell reserving process without introducing new overhead on the network
- Maintaining a good end-to-end communication latency

# Outline

# IEEE802.15.4e and 6top

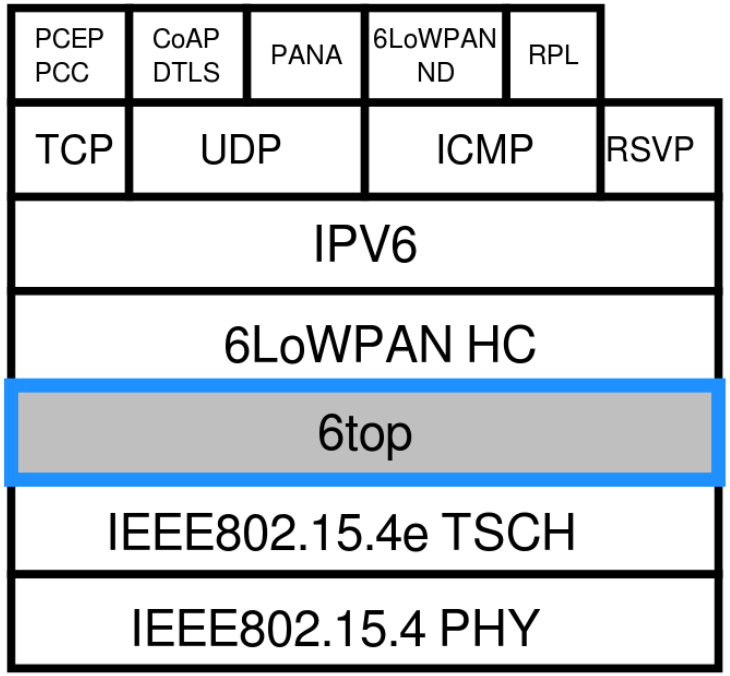
## IEEE802.15.4e & 6top

- 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

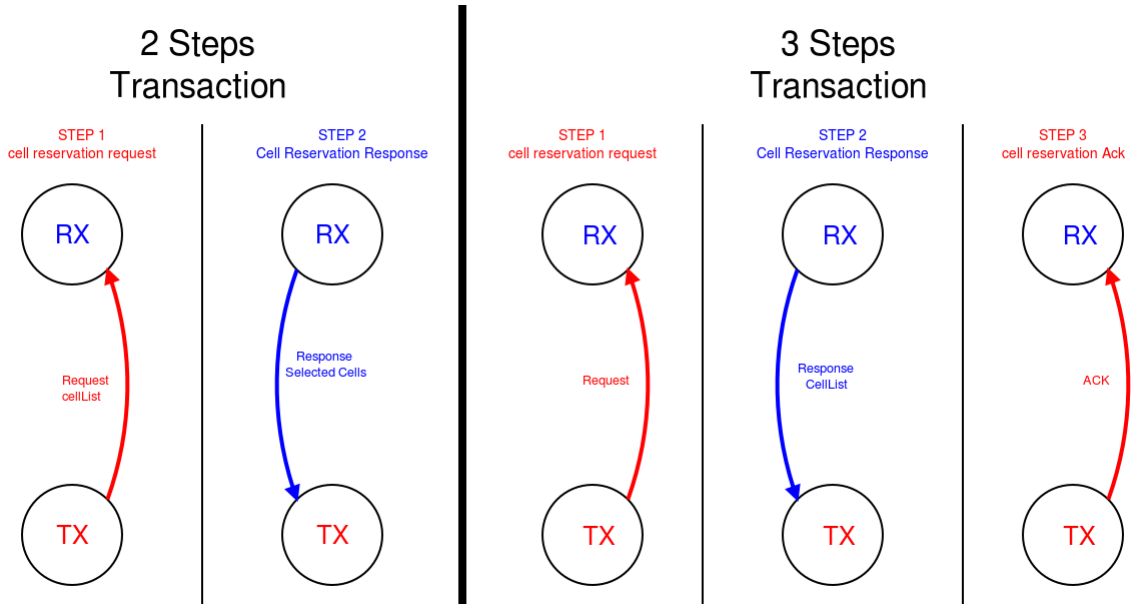
- orchestrates all communications using the TSCH schedule.
- allows the nodes to request for new TSCH cells and update the TSCH schedule table accordingly.
- 6P enables the distributed scheduling in 6TiSCH network.



# IEEE802.15.4e and 6top

## IEEE802.15.4e & 6top

- 6top uses transaction to 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 recieved by the neighbor nodes by dropped due too MAC filtering of the messages.



# Outline

# MAC Filtering

## IEEE802.15.4e & 6top

- Consist of level of filters, the first and three levels are related to the correctness of the frame and the mode of the network.
- The fourth level of filters will check the frame destenation and drop it accordingly.
- We can Modify the MAC filtering so that we can recieve the frames from 6top.

# 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.

# Outline

# Proposed Mechanism Criteria

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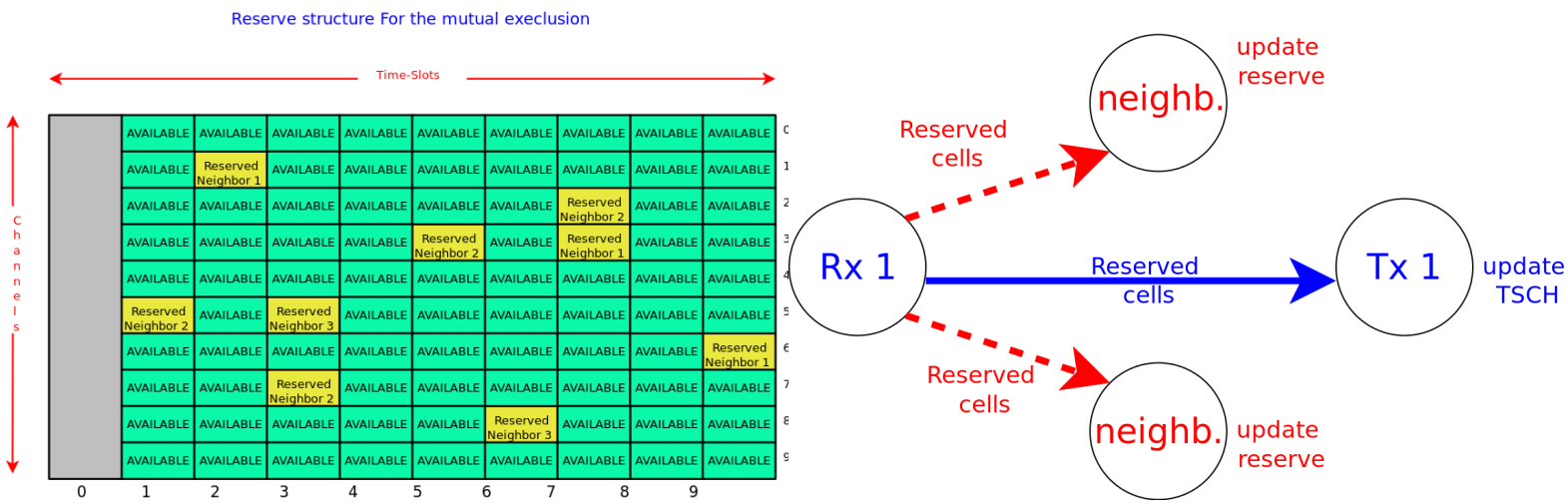
# Reserve Table

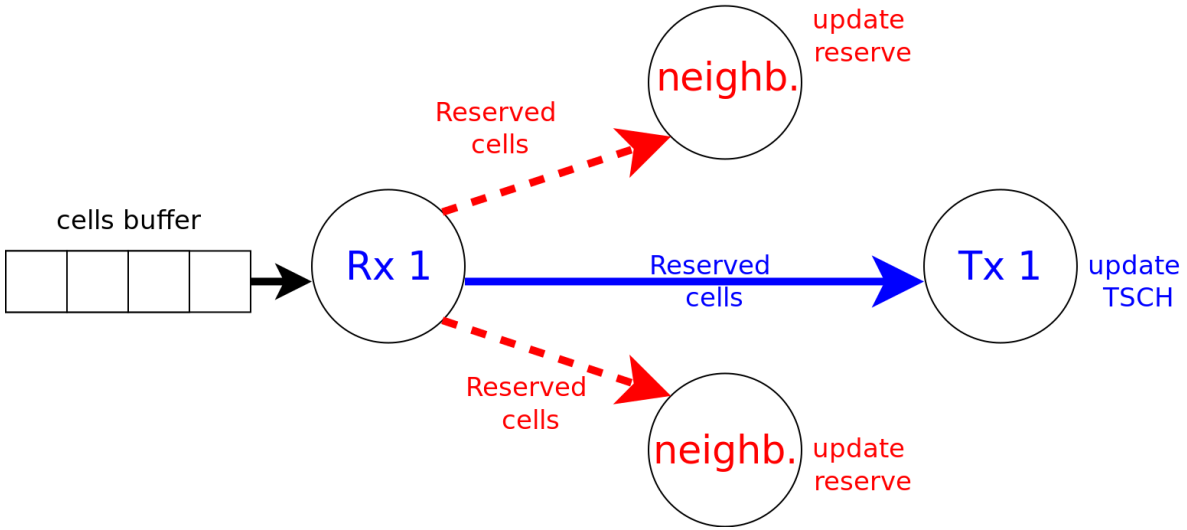
- The nodes will recieve the 6top transaction from the neighbor nodes.
- The cells reserved by neighbors will be reserved by a structure similar to TSCH table.
- Scheduling function will avoid selecting cells found in this structure.
- 6top will control this table so any scheduling function can be used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

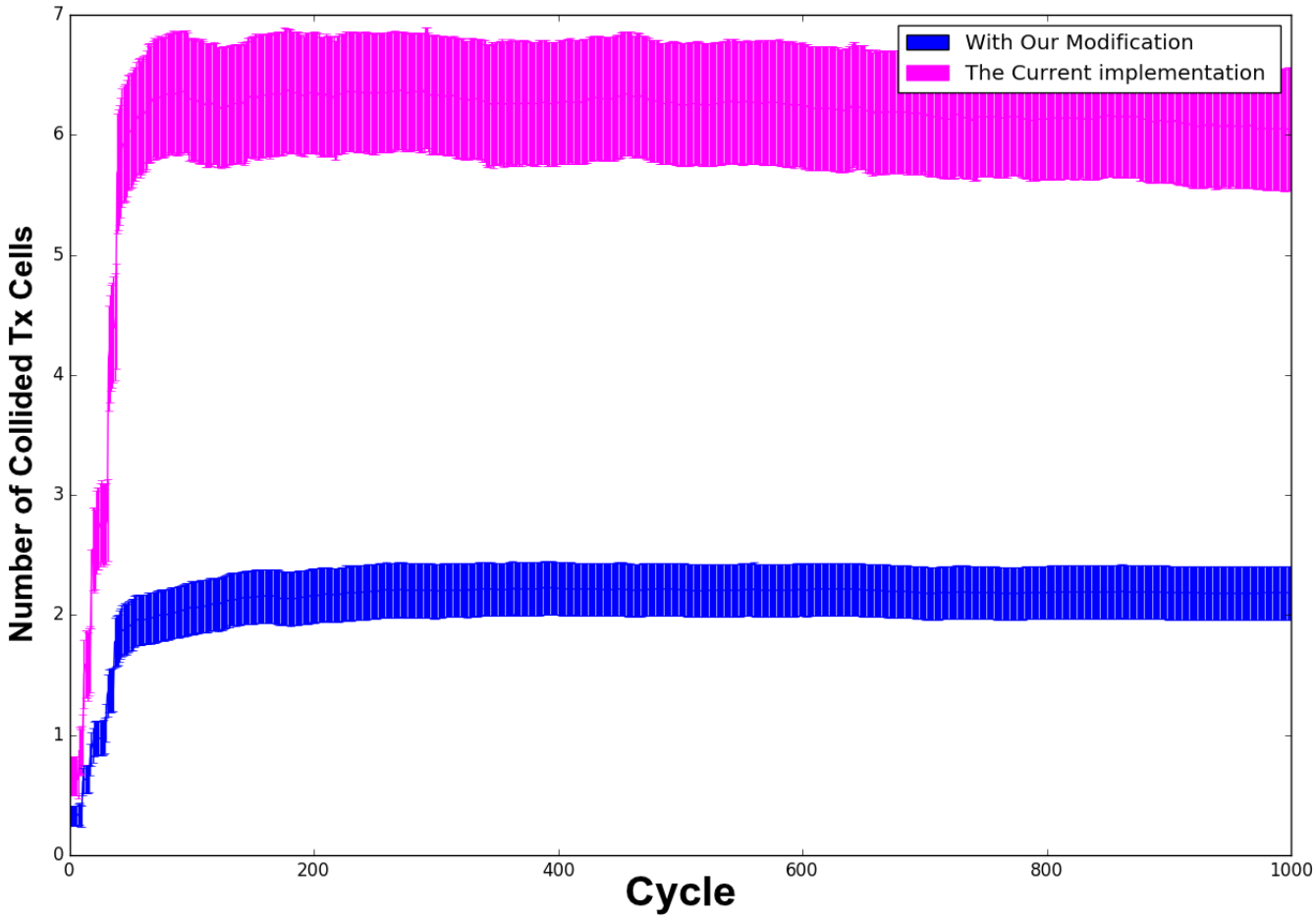



Figure: Simulation of the Number of Collided Txs Cells as Function of Cycle Number (Time)

# Results

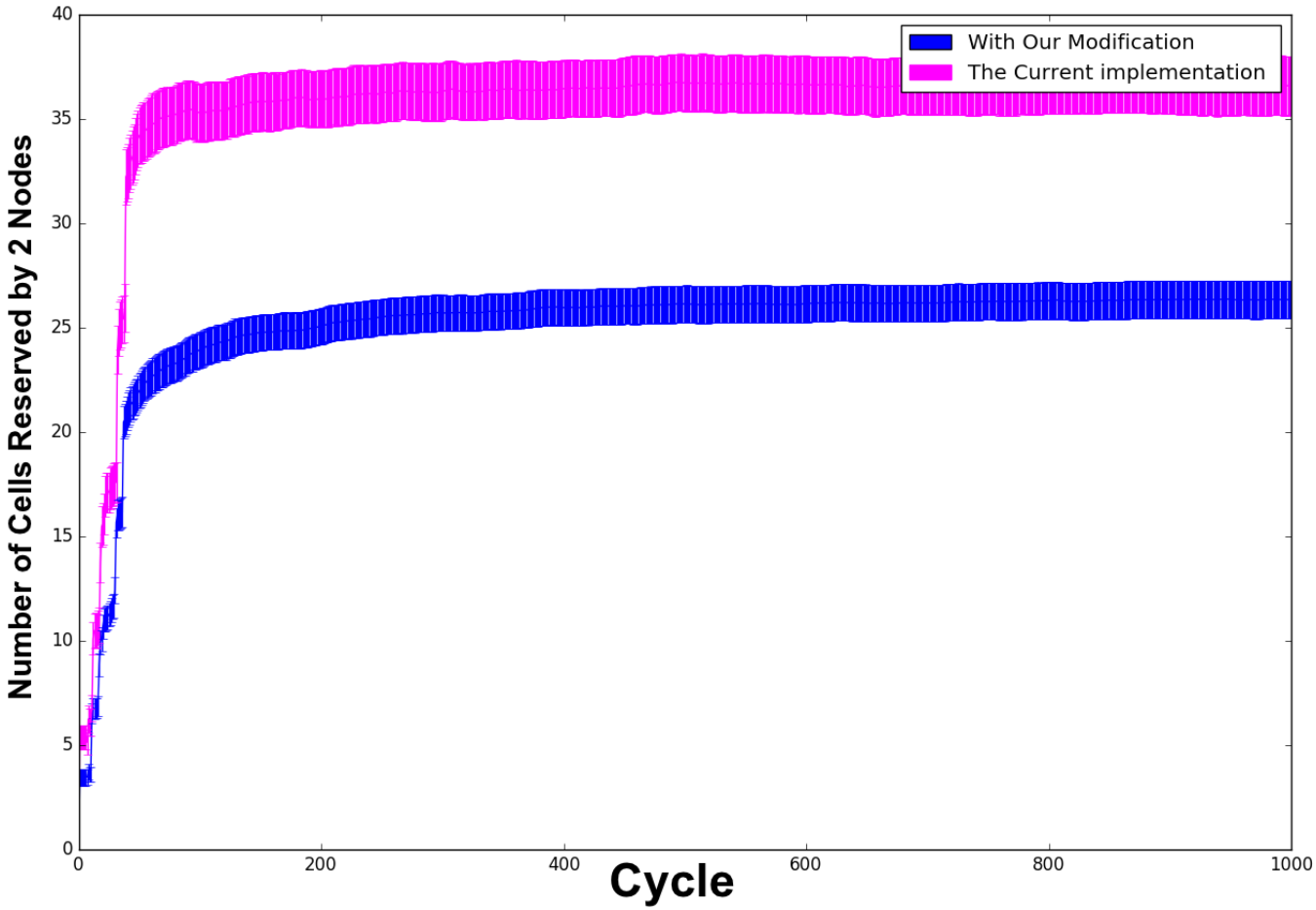



Figure: Simulation of the Number of Cells Reserved by 2 Nodes as Function of Cycle Number (Time)

# Related Work Results comparison

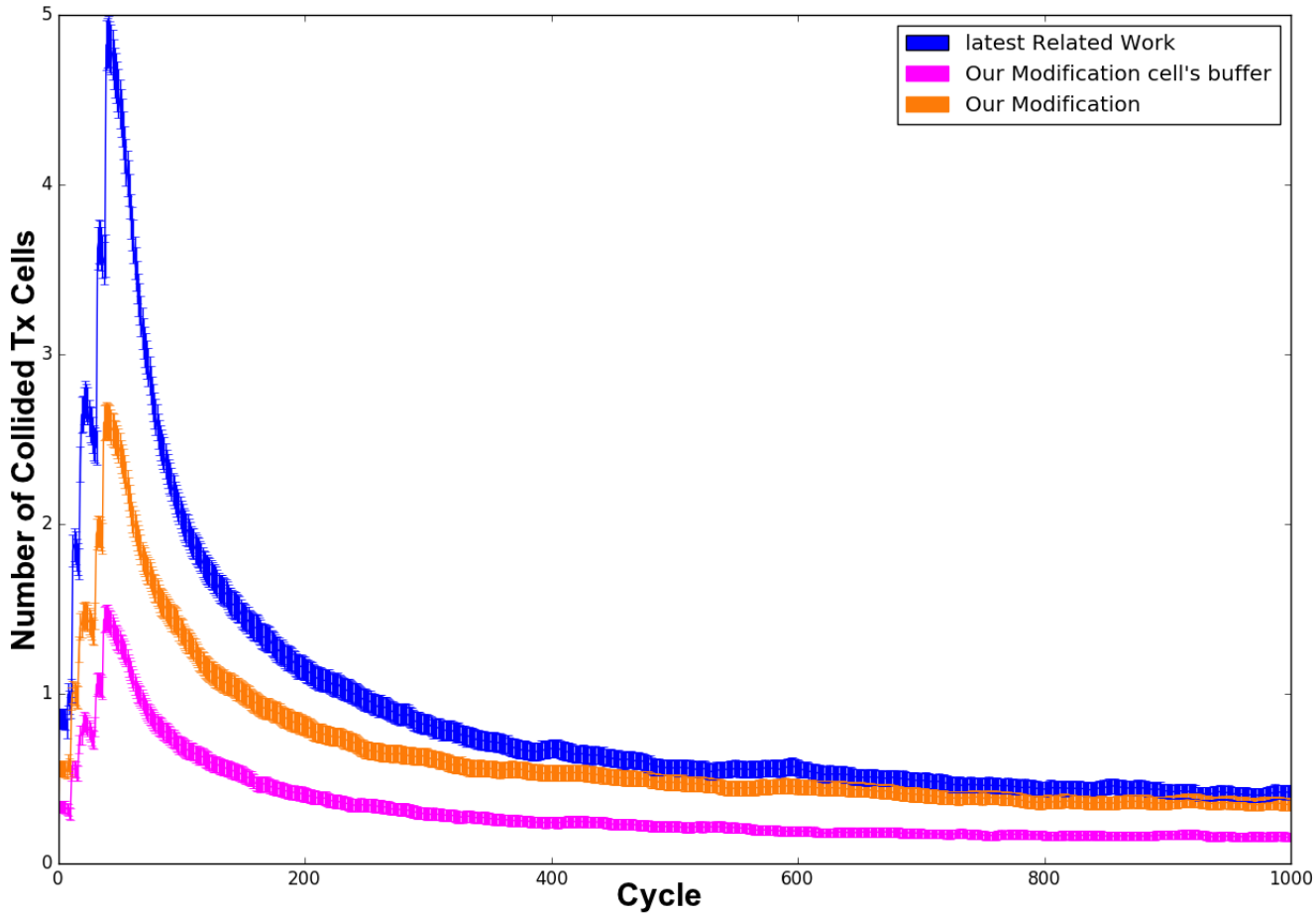



Figure: Simulation of the Number of Collided Txs Cells as Function of Cycle Number (Time) - comparison with the housekeeping approach

# 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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