Collision Prevention in Distributed 6TiSCH Networks

Ali Jawad Fahs

Université Grenoble Alpes (UGA) - UFR IM^{2}AG
Laboratoire d'Informatique de Grenoble (LIG), Team Drakkar
VERIMAG,Synchrone
Supervised by : Olivier Alphand, Franck Rousseau
Karine Altisen, Stéphane Devismes

Master thesis, 21st of June,2017

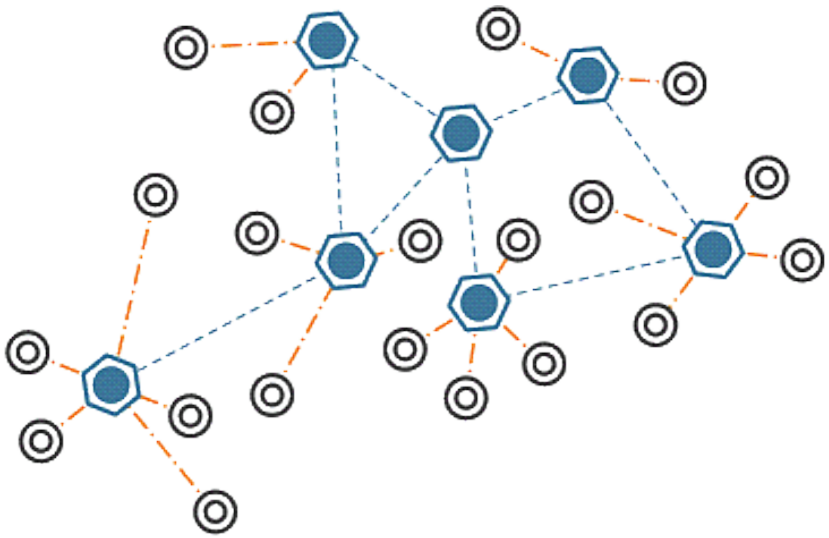
Outline

Outline

General Introduction

IoT & Wireless Sensor Networks

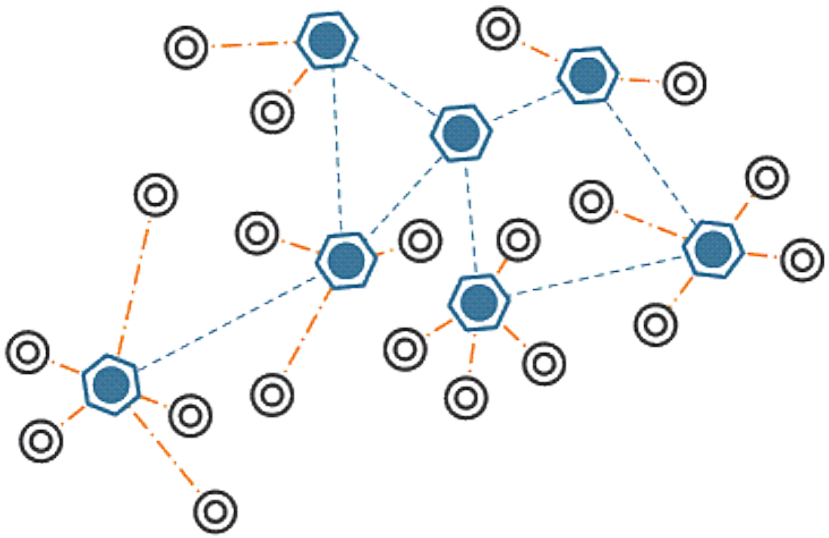
- Network technologies and IoT.



General Introduction

IoT & Wireless Sensor Networks

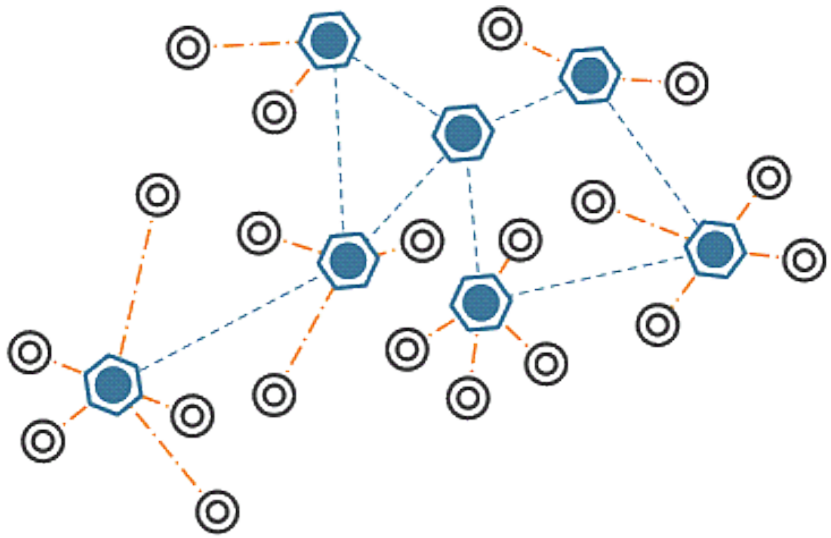
- Network technologies and IoT.
- WSN: standardization of IoT nodes communication.



General Introduction

IoT & Wireless Sensor Networks

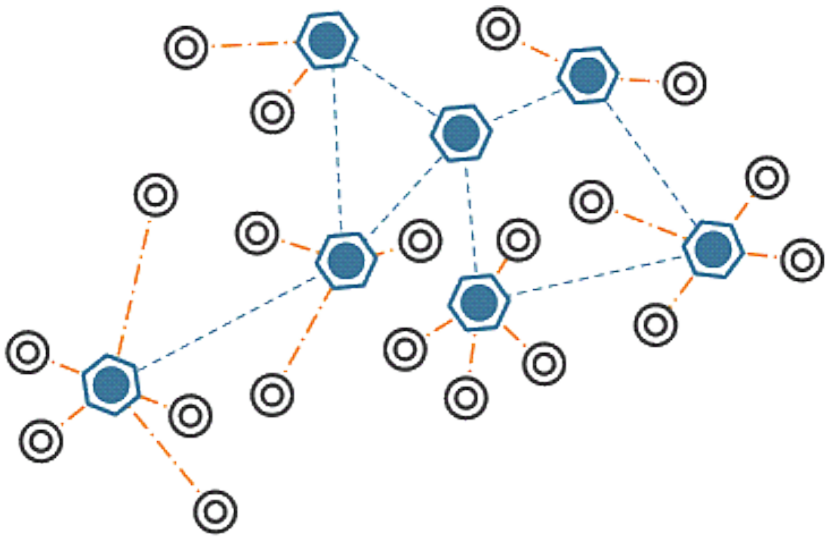
- Network technologies and IoT.
- WSN: standardization of IoT nodes communication.
- Main contributions are : low power consumption, low cost.



General Introduction

IoT & Wireless Sensor Networks

- Network technologies and IoT.
- WSN: standardization of IoT nodes communication.
- Main contributions are : low power consumption, low cost.
- IEEE802.15.4 one of the main standards of WSN.

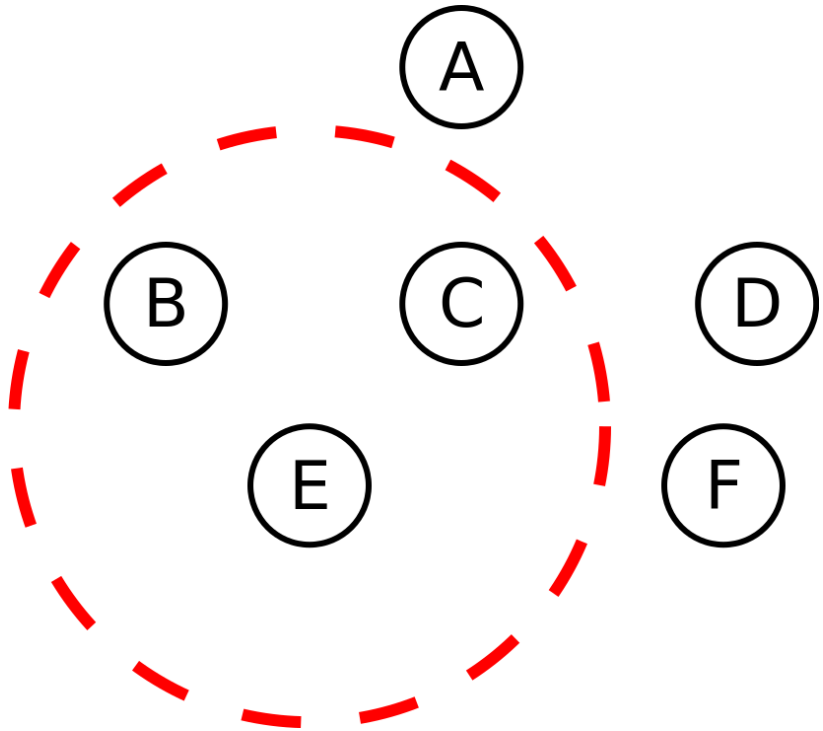


General intoduction

IEEE802.15.4

Converge Cast Structure

- Nodes radio ranges defines the neighborhood.

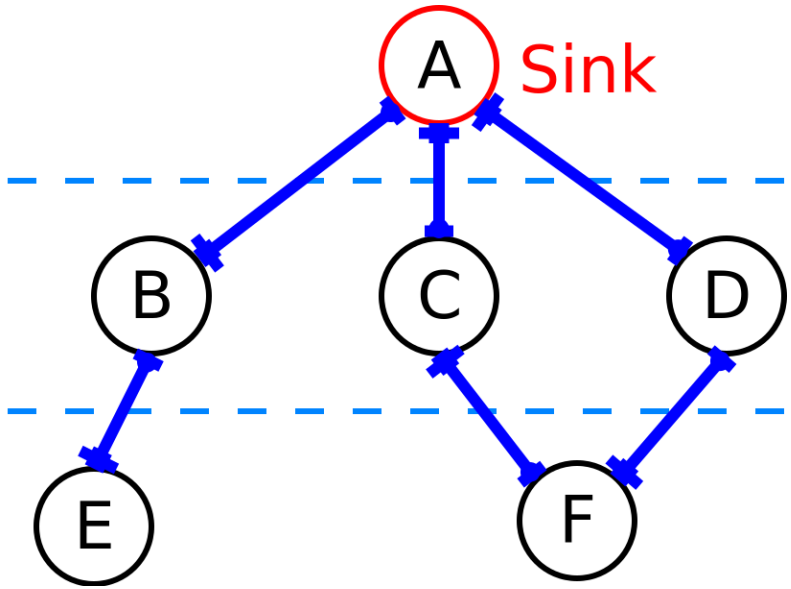


General intoduction

IEEE802.15.4

Converge Cast Structure

- Nodes radio ranges defines the neighborhood.
- Sink is selected.

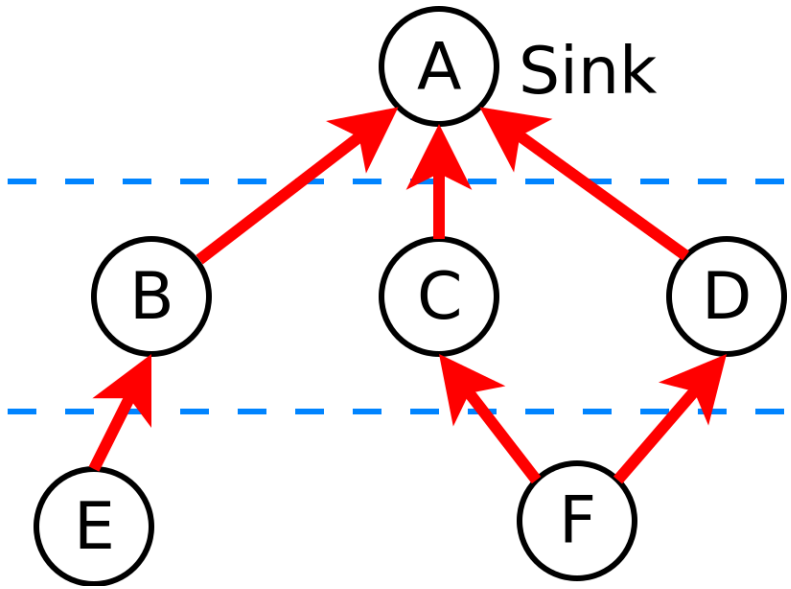


General intoduction

IEEE802.15.4

Converge Cast Structure

- Nodes radio ranges defines the neighborhood.
- Sink is selected.
- Packets are forwarded toward the sink.

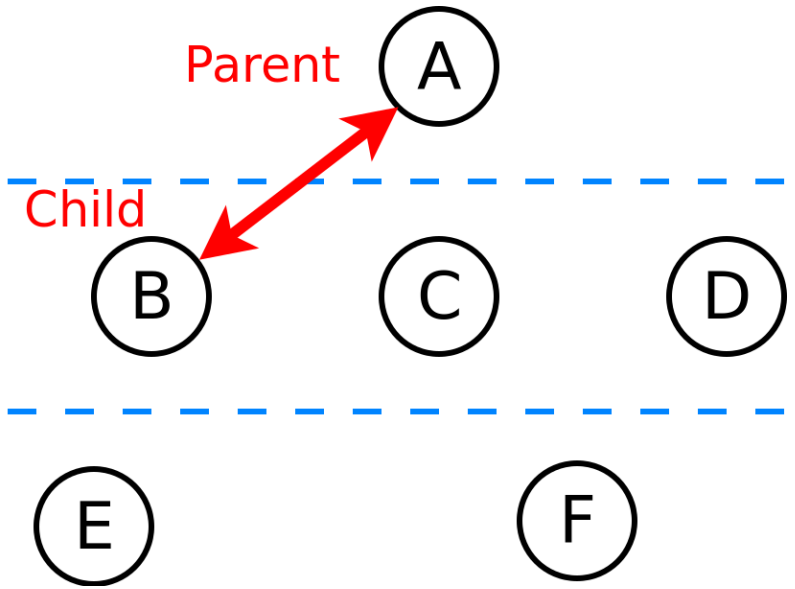


General intoduction

IEEE802.15.4

Converge Cast Structure

- Nodes radio ranges defines the neighborhood.
- Sink is selected.
- Packets are forwarded toward the sink.
- Communication pairs.



Outline

IEEE802.15.4 Protocols

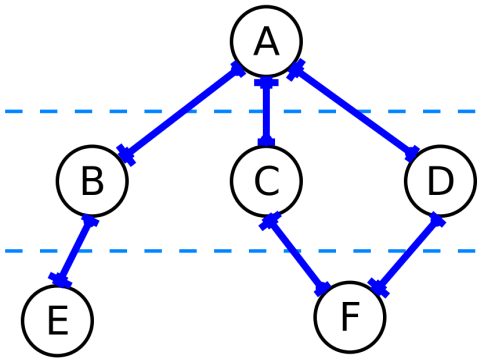
IEEE802.15.4e TSCH

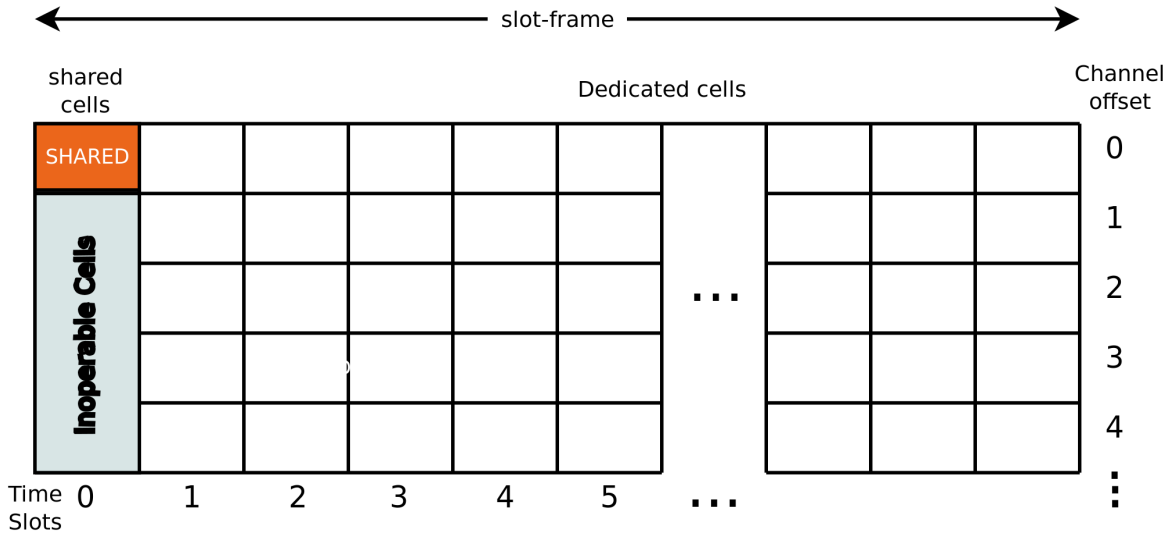
- IEEE802.15.4 defines the MAC and PHY layers.

IEEE802.15.4 Protocols

IEEE802.15.4e TSCH

- IEEE802.15.4 defines the MAC and PHY layers.
- TSCH is an extension of the MAC layer of IEEE802.15.4.

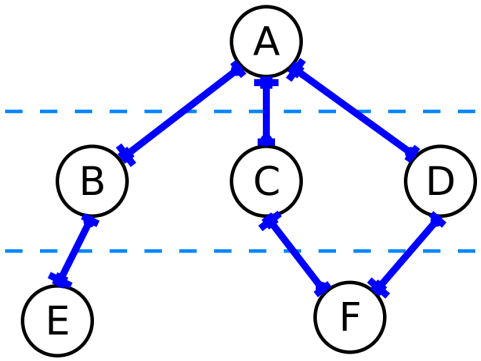


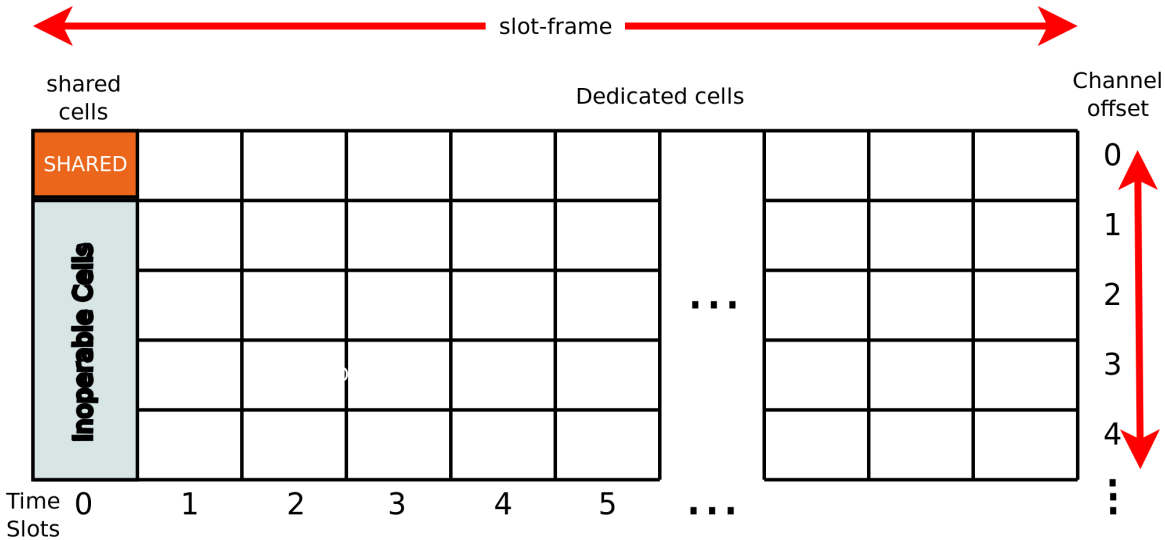


IEEE802.15.4 Protocols

IEEE802.15.4e TSCH

- IEEE802.15.4 defines the MAC and PHY layers.
- TSCH is an extension of the MAC layer of IEEE802.15.4.
- Time/Frequency multiplexing of the bandwidth.

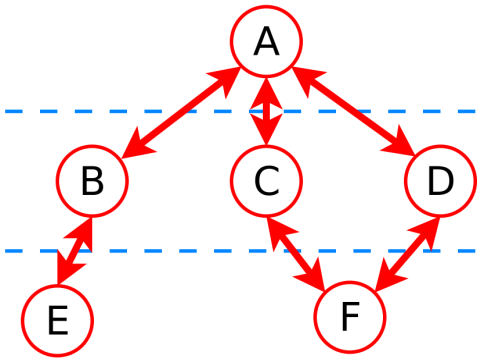


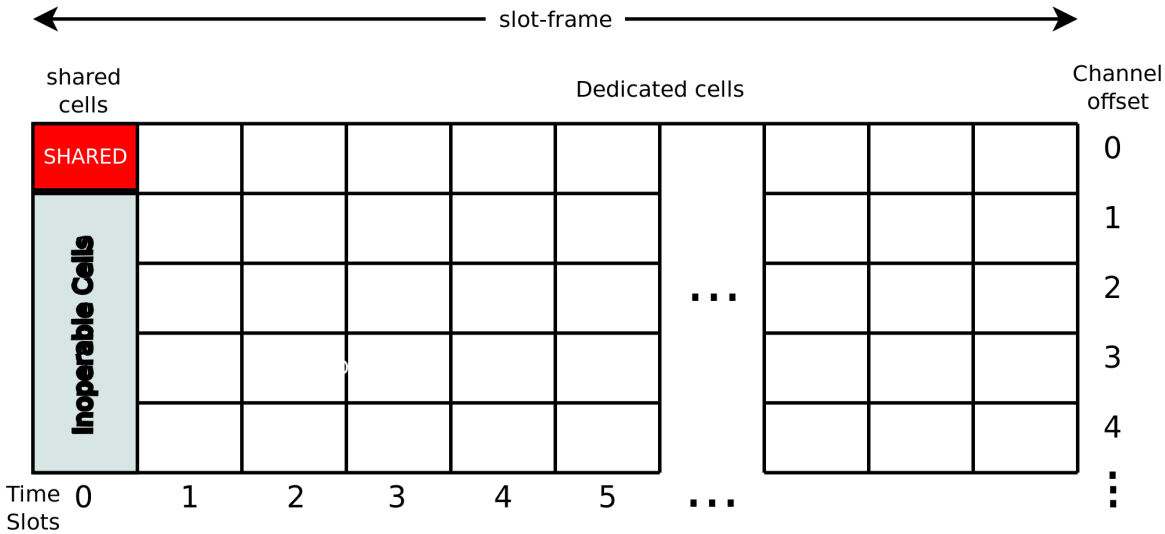


IEEE802.15.4 Protocols

IEEE802.15.4e TSCH

- IEEE802.15.4 defines the MAC and PHY layers.
- TSCH is an extension of the MAC layer of IEEE802.15.4.
- Time/Frequency multiplexing of the bandwidth.
- Shared cells.

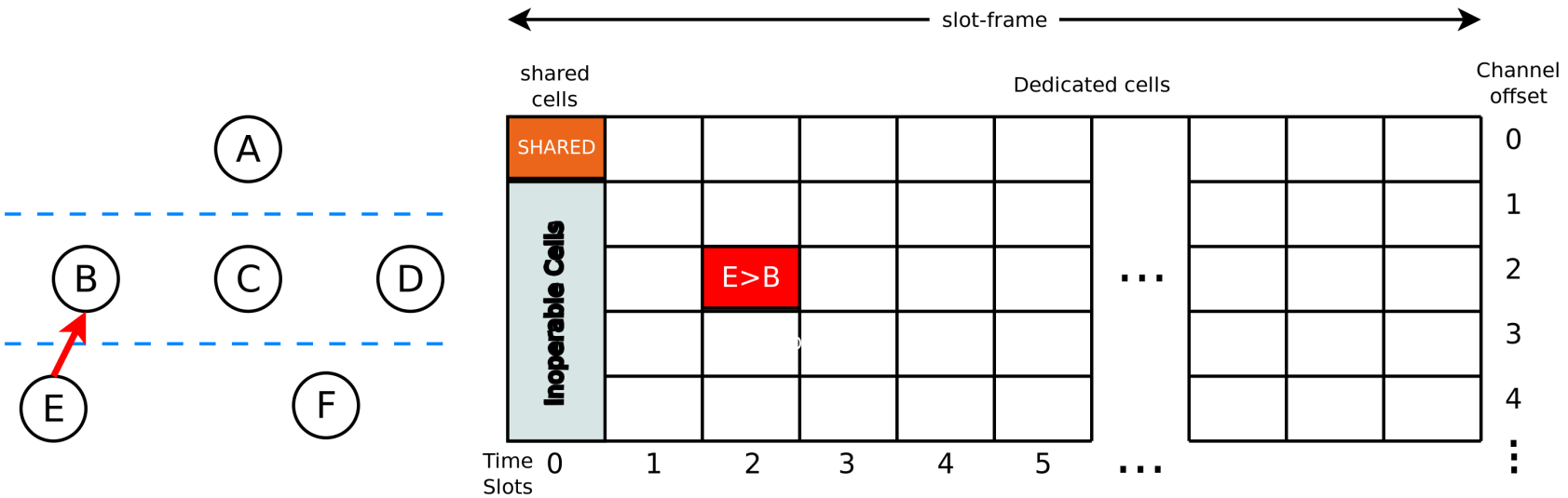




IEEE802.15.4 Protocols

IEEE802.15.4e TSCH

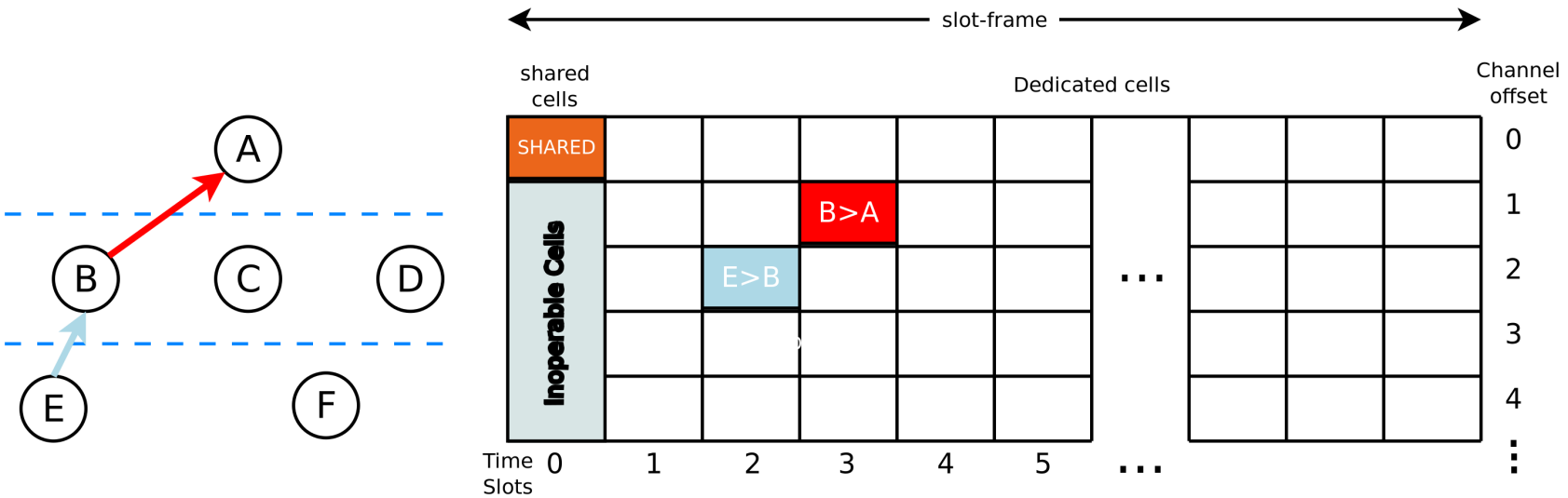
- IEEE802.15.4 defines the MAC and PHY layers.
- TSCH is an extension of the MAC layer of IEEE802.15.4.
- Time/Frequency multiplexing of the bandwidth.
- Shared cells.
- Dedicated cells.



IEEE802.15.4 Protocols

IEEE802.15.4e TSCH

- IEEE802.15.4 defines the MAC and PHY layers.
- TSCH is an extension of the MAC layer of IEEE802.15.4.
- Time/Frequency multiplexing of the bandwidth.
- Shared cells.
- Dedicated cells.



IEEE802.15.4 Protocols

6TiSCH

- IEEE802.15.4 left the management of TSCH for other Protocols.

IEEE802.15.4 Protocols

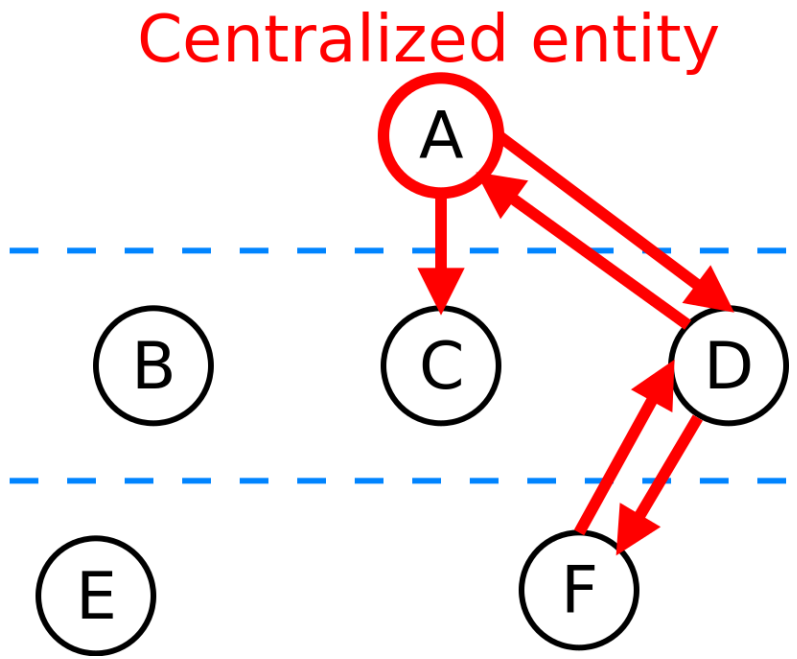
6TiSCH

- IEEE802.15.4 left the management of TSCH for other Protocols.
- 6TiSCH offered the integration of TSCH over IPv6.

IEEE802.15.4 Protocols

6TiSCH

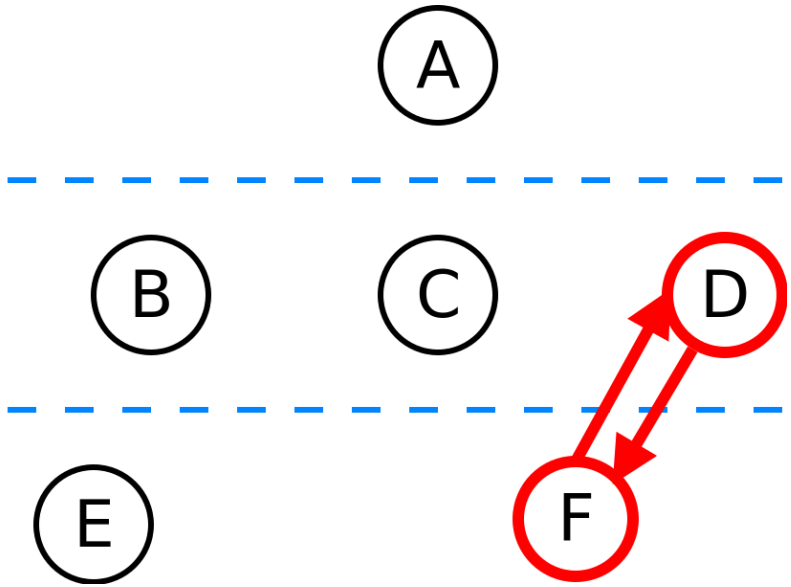
- IEEE802.15.4 left the management of TSCH for other Protocols.
- 6TiSCH offered the integration of TSCH over IPv6.
- 6TiSCH operation sublayer (6top) offered the management of TSCH:
  - Centralized algorithm.



IEEE802.15.4 Protocols

6TiSCH

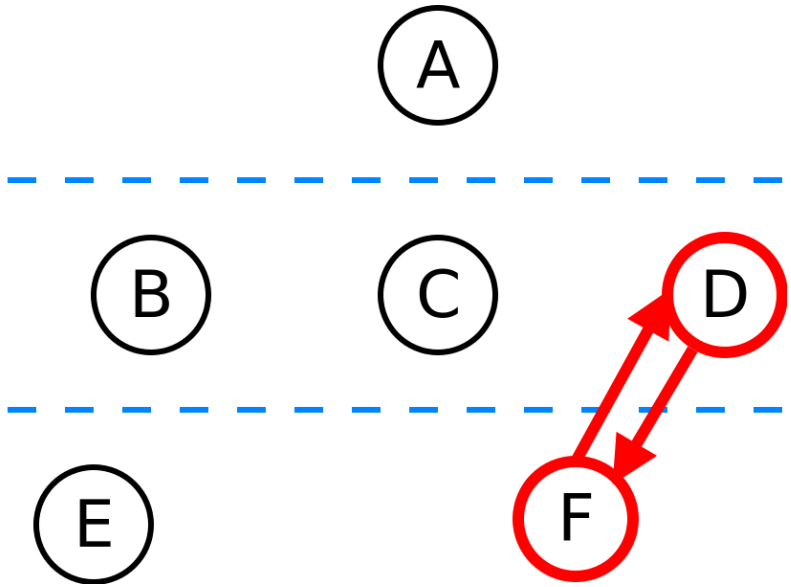
- IEEE802.15.4 left the management of TSCH for other Protocols.
- 6TiSCH offered the integration of TSCH over IPv6.
- 6TiSCH operation sublayer (6top) offered the management of TSCH:
  - Centralized algorithm.
  - Distributed algorithm.



IEEE802.15.4 Protocols

6TiSCH

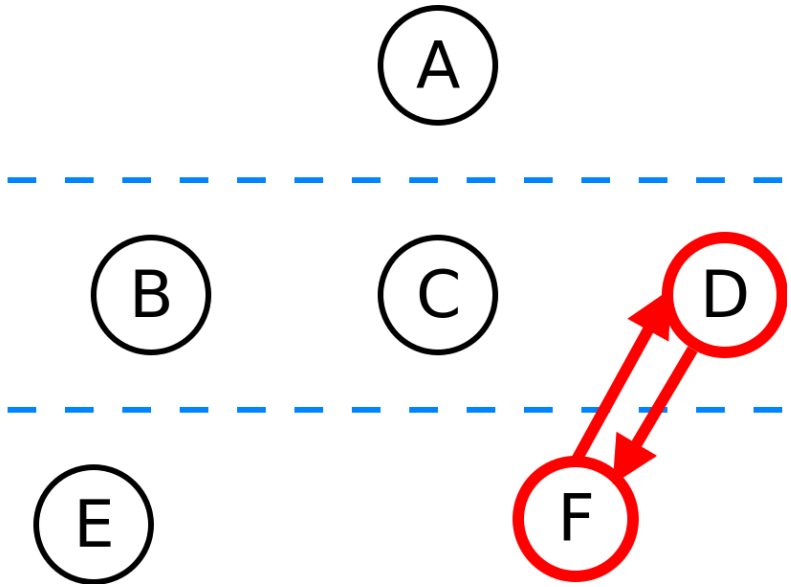
- IEEE802.15.4 left the management of TSCH for other Protocols.
- 6TiSCH offered the integration of TSCH over IPv6.
- 6TiSCH operation sublayer (6top) offered the management of TSCH:
  - Centralized algorithm.
  - Distributed algorithm.
- 6top contains:
  - 6top transactions.



IEEE802.15.4 Protocols

6TiSCH

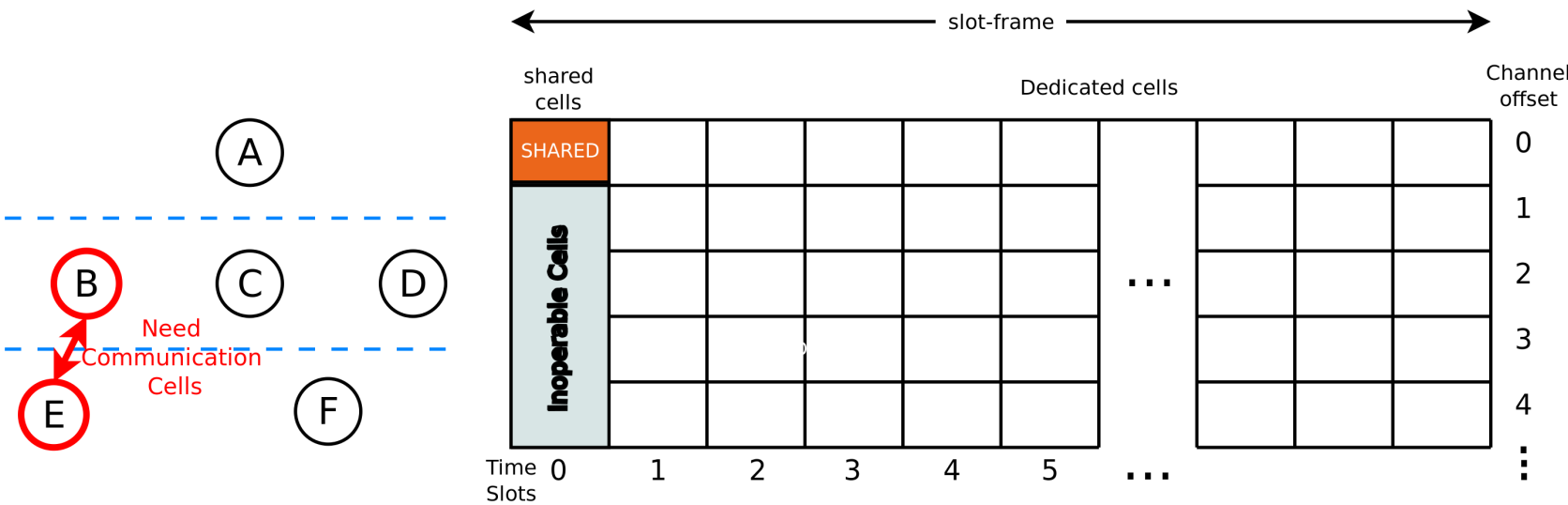
- IEEE802.15.4 left the management of TSCH for other Protocols.
- 6TiSCH offered the integration of TSCH over IPv6.
- 6TiSCH operation sublayer (6top) offered the management of TSCH:
  - Centralized algorithm.
  - Distributed algorithm.
- 6top contains:
  - 6top transactions.
  - Scheduling function.



IEEE802.15.4 Protocols

Cell Reservation Process

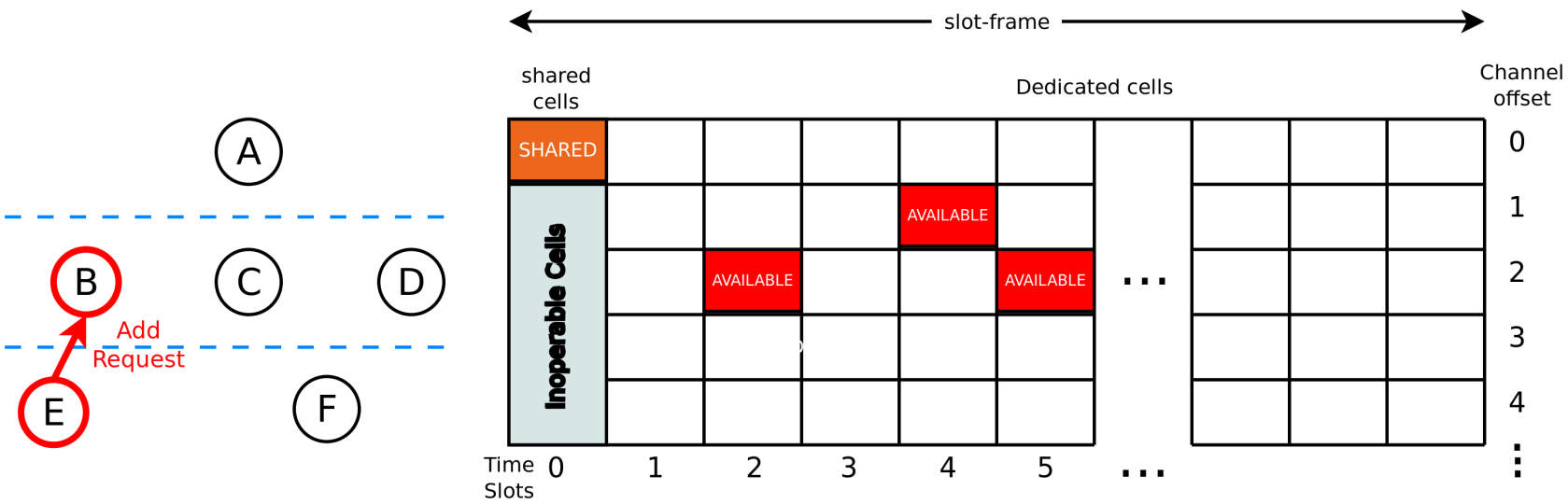
- Scheduling function decides new cell should be assigned.



IEEE802.15.4 Protocols

Cell Reservation Process

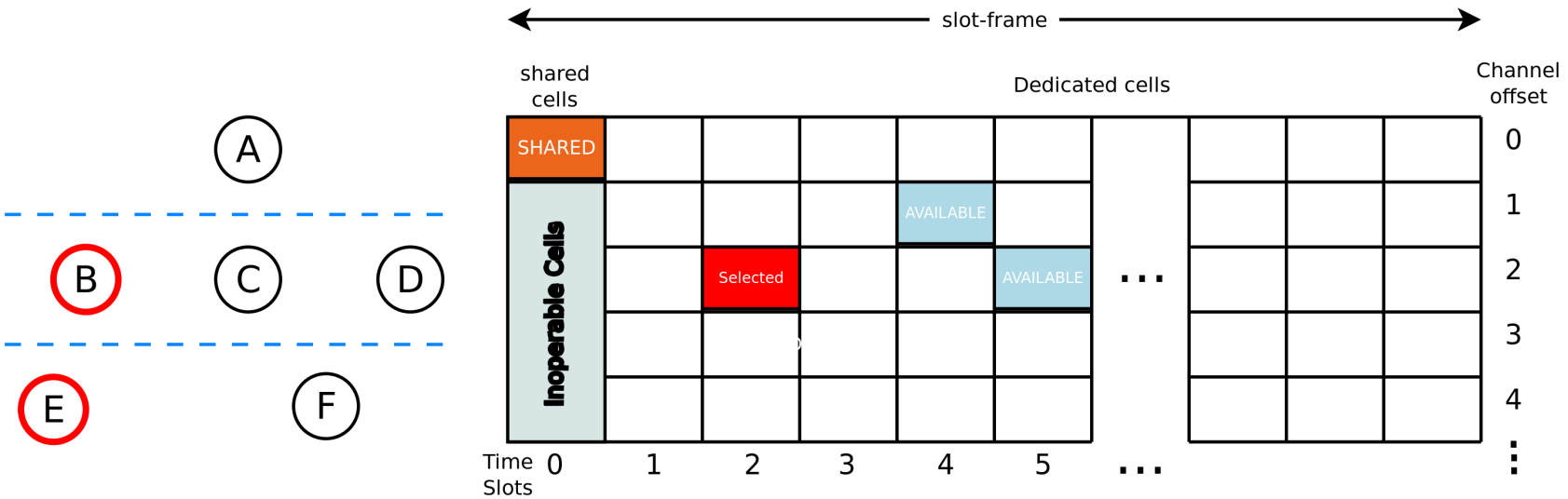
- Scheduling function decides new cell should be assigned.
- Child node sends an Add request.



IEEE802.15.4 Protocols

Cell Reservation Process

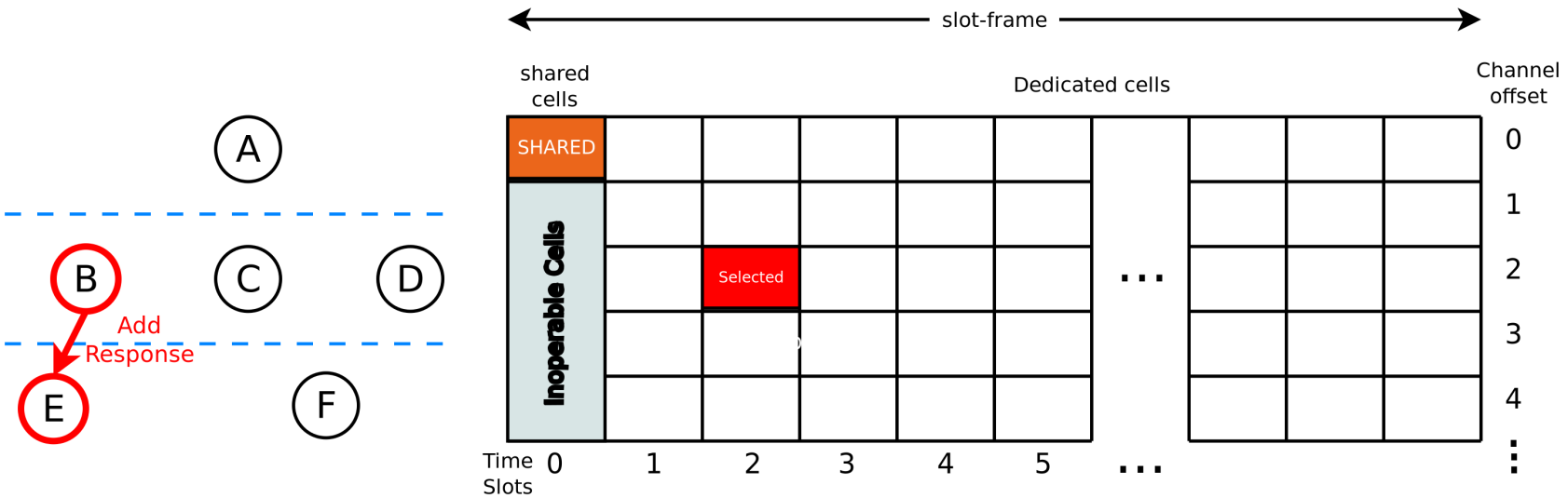
- Scheduling function decides new cell should be assigned.
- Child node sends an Add request.
- Scheduling function decides which cells to be selected.



IEEE802.15.4 Protocols

Cell Reservation Process

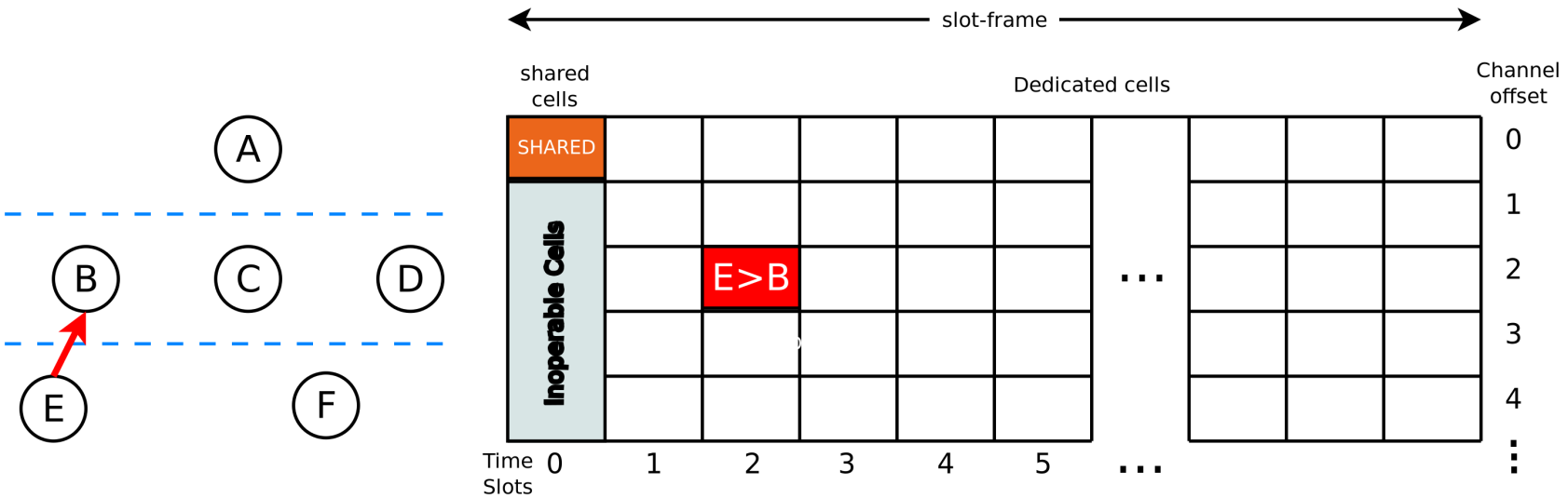
- Scheduling function decides new cell should be assigned.
- Child node sends an Add request.
- Scheduling function decides which cells to be selected.
- Parent node replies with an Add response.



IEEE802.15.4 Protocols

Cell Reservation Process

- Scheduling function decides new cell should be assigned.
- Child node sends an Add request.
- Scheduling function decides which cells to be selected.
- Parent node replies with an Add response.
- Cell is added and communication start.



Outline

Project challenges & Objectives

Collision in Dedicated Cells

- Collision free Dedicated Cells?

Project challenges & Objectives

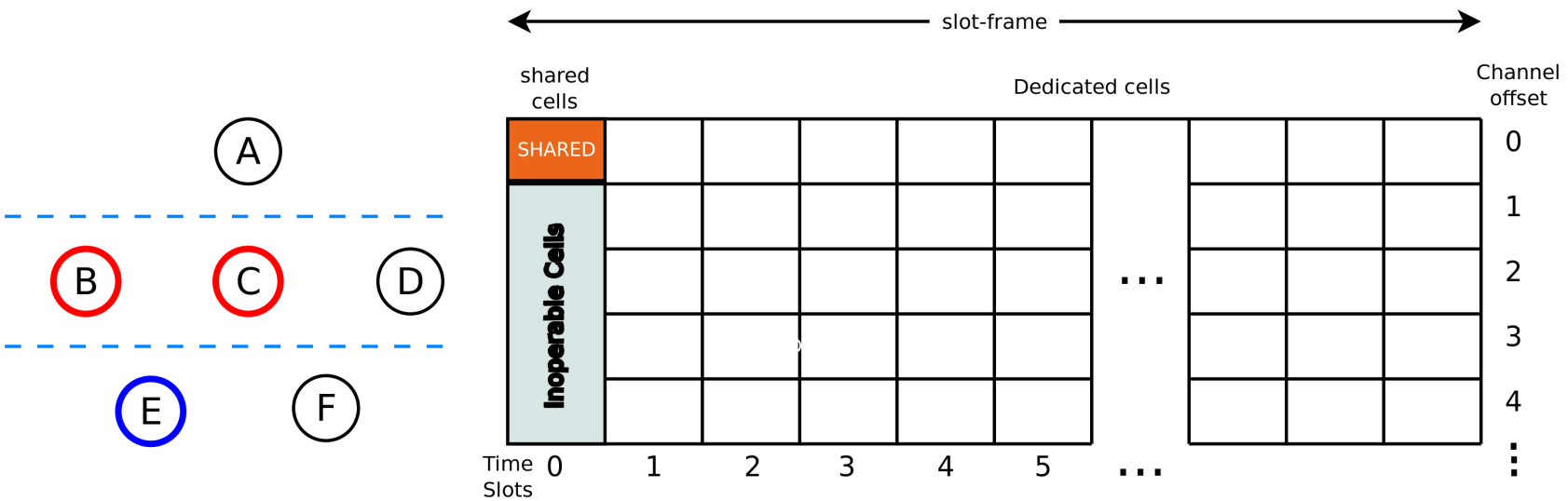
Collision in Dedicated Cells

- Collision free Dedicated Cells?
- No central entity in distributed approach.

Project challenges & Objectives

Collision in Dedicated Cells

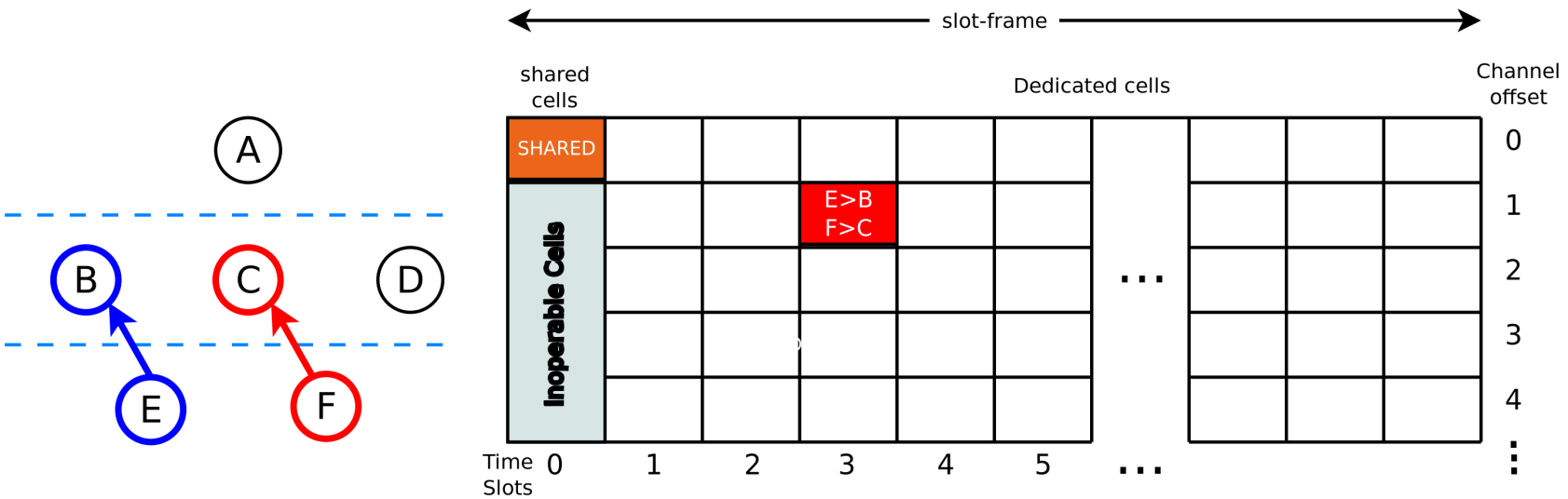
- Collision free Dedicated Cells?
- No central entity in distributed approach.
- Neighbor nodes can select the same communication cell.



Project challenges & Objectives

Collision in Dedicated Cells

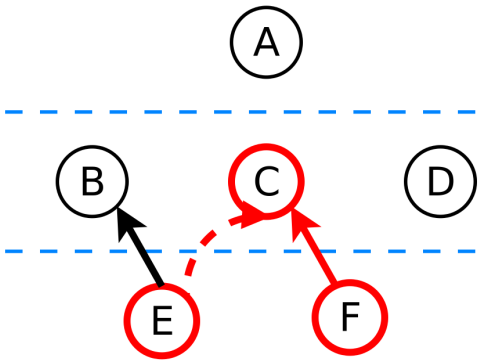
- Collision free Dedicated Cells?
- No central entity in distributed approach.
- Neighbor nodes can select the same communication cell.

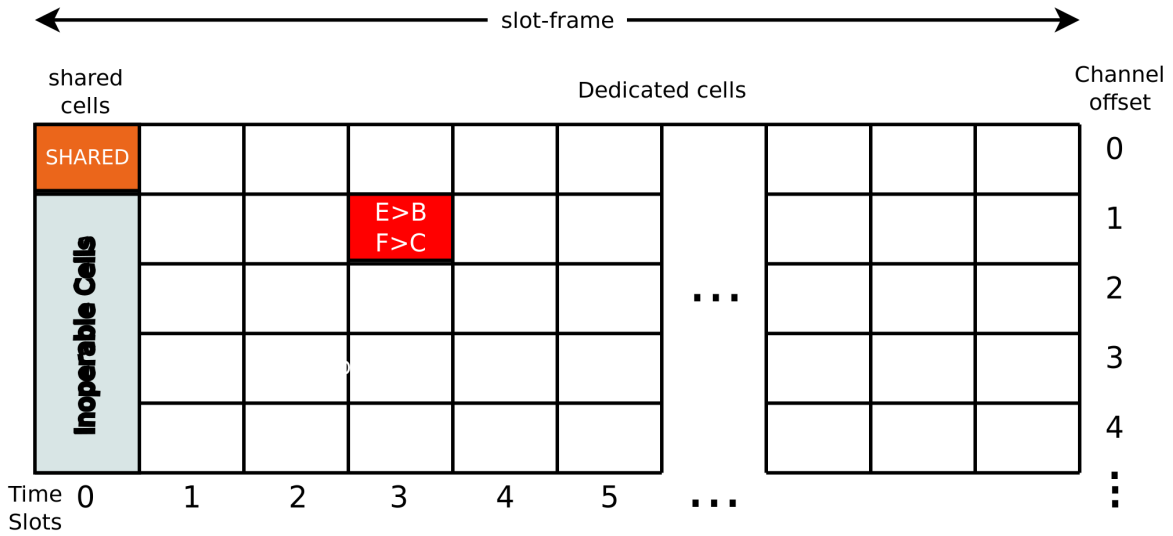


Project challenges & Objectives

Collision in Dedicated Cells

- Collision free Dedicated Cells?
- No central entity in distributed approach.
- Neighbor nodes can select the same communication cell.
- Collision at the reception Node.

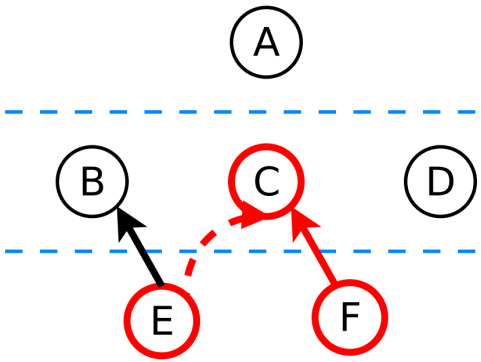


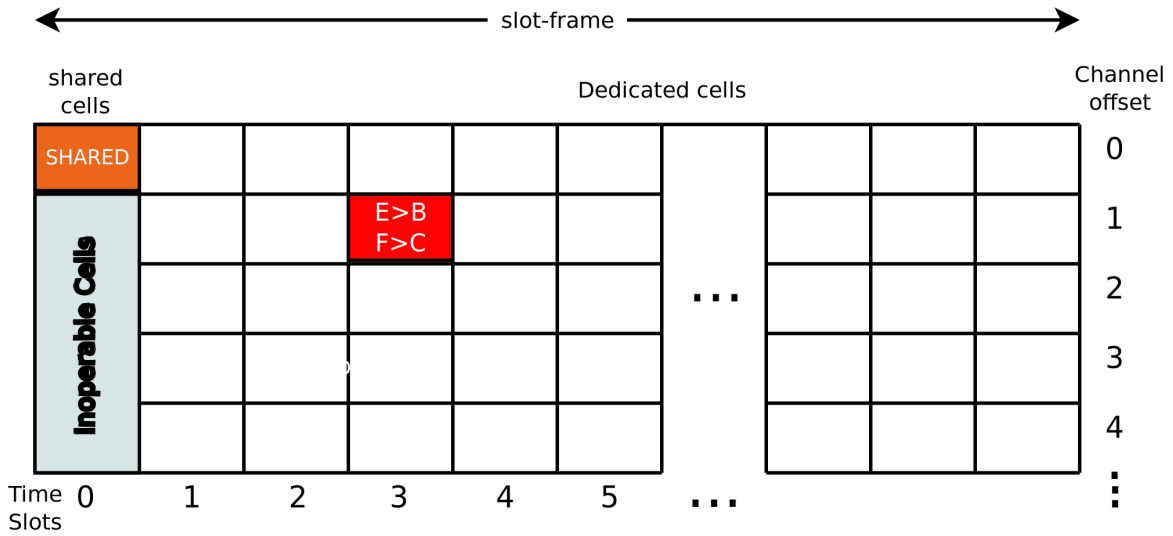


Project challenges & Objectives

Collision in Dedicated Cells

- Collision free Dedicated Cells?
- No central entity in distributed approach.
- Neighbor nodes can select the same communication cell.
- Collision at the reception Node.
- Collision in terms of power, latency.





Project challenges & Objectives

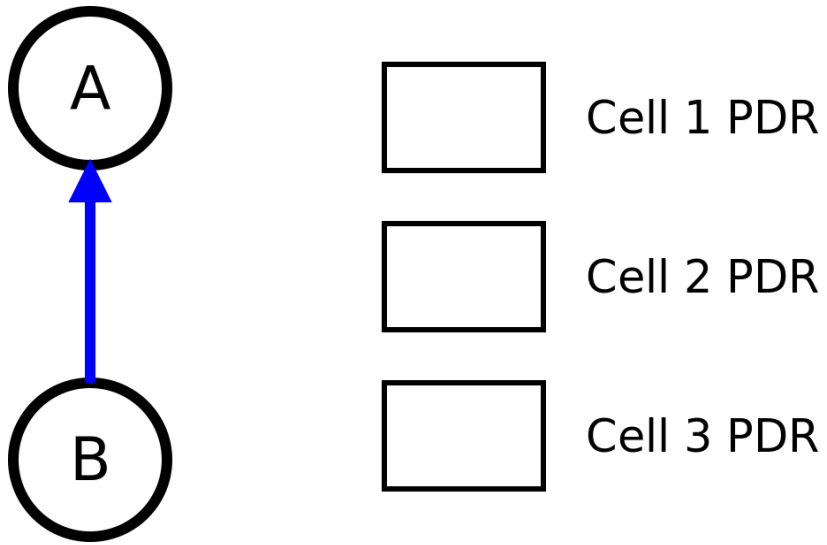
Collision in Dedicated Cells

- Housekeeping approach and cell relocation.

Project challenges & Objectives

Collision in Dedicated Cells

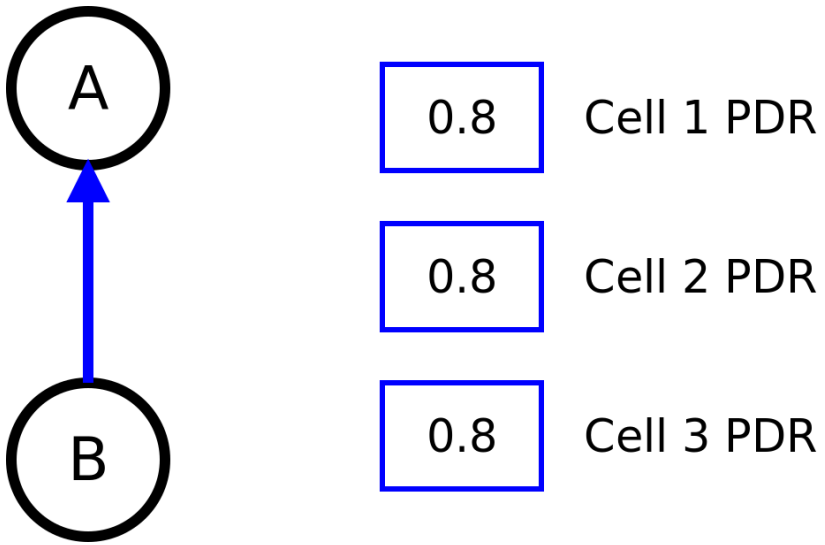
- Housekeeping approach and cell relocation.
- Tx housekeeping.



Project challenges & Objectives

Collision in Dedicated Cells

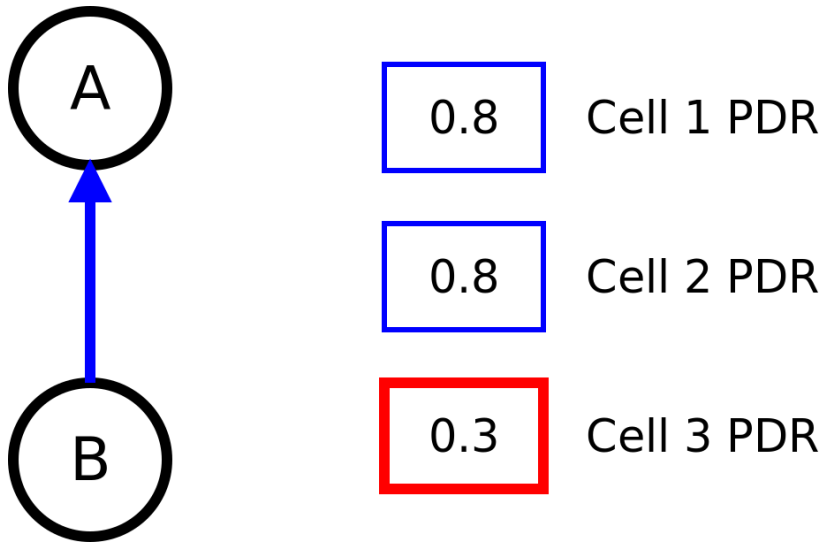
- Housekeeping approach and cell relocation.
- Tx housekeeping.



Project challenges & Objectives

Collision in Dedicated Cells

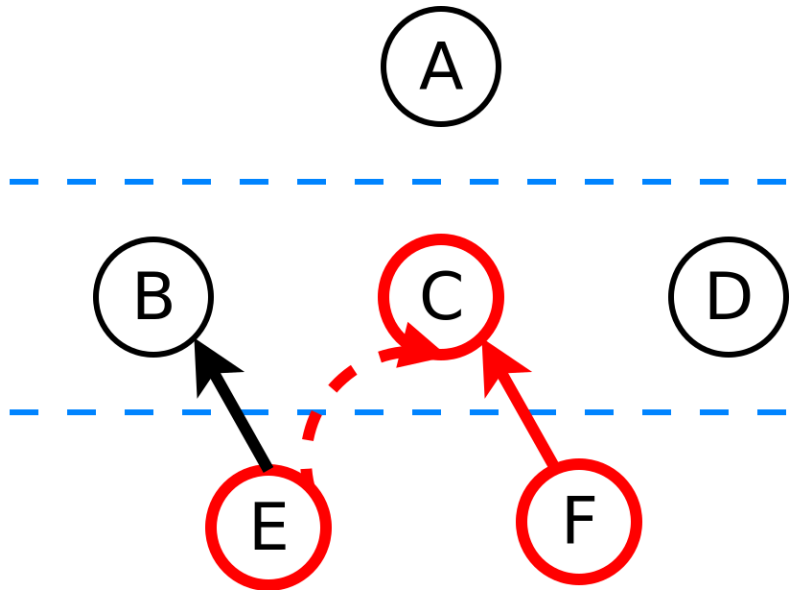
- Housekeeping approach and cell relocation.
- Tx housekeeping.



Project challenges & Objectives

Collision in Dedicated Cells

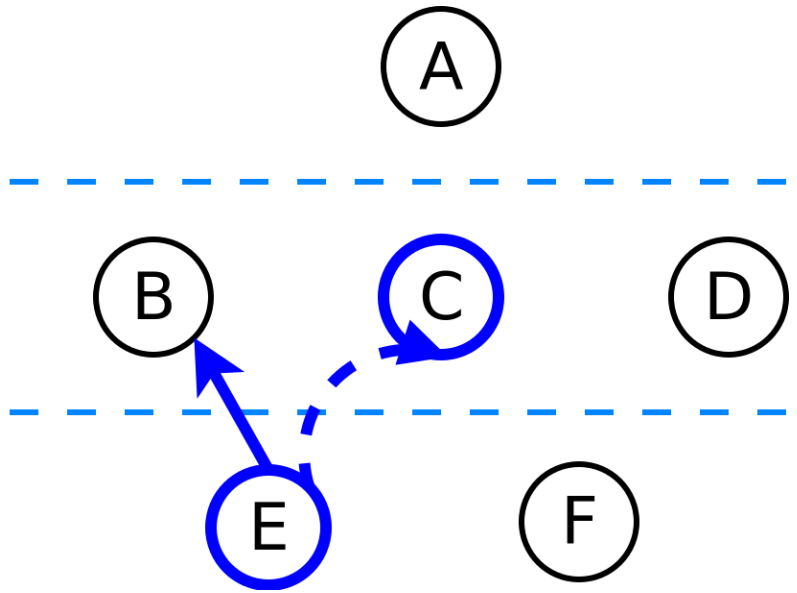
- Housekeeping approach and cell relocation.
- Tx housekeeping.
- Rx housekeeping.



Project challenges & Objectives

Collision in Dedicated Cells

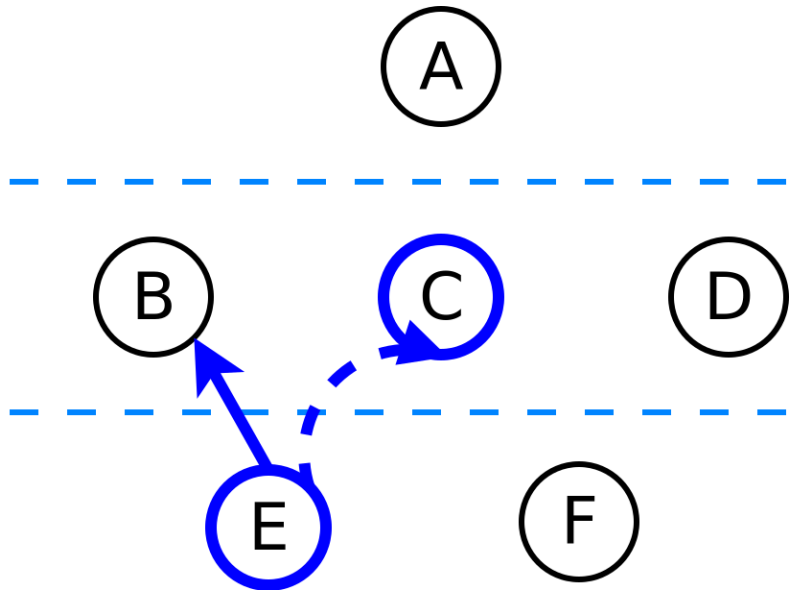
- Housekeeping approach and cell relocation.
- Tx housekeeping.
- Rx housekeeping.



Project challenges & Objectives

Collision in Dedicated Cells

- Housekeeping approach and cell relocation.
- Tx housekeeping.
- Rx housekeeping.
- Dealing with collisions after they occur. Good idea ?



Project Objectives

- Reducing the collisions in TSCH dedicated cells.

Project Objectives

- Reducing the collisions in TSCH dedicated cells.
- Modifying the Cell reserving process without introducing new overhead on the network

Project Objectives

- Reducing the collisions in TSCH dedicated cells.
- Modifying the Cell reserving process without introducing new overhead on the network
- Creating a flexible mechanism, compatible with all scheduling functions

Outline

Using 6top Transaction

Why?

- Submitted in the shared slot.

Using 6top Transaction

Why?

- Submitted in the shared slot.
- Contains the reserved cells.

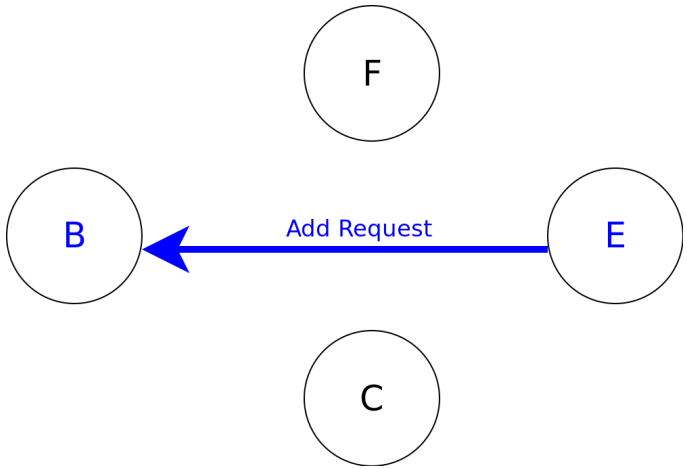
Using 6top Transaction

Why?

- Submitted in the shared slot.
- Contains the reserved cells.

How?

- The child node Sends an Add Request.



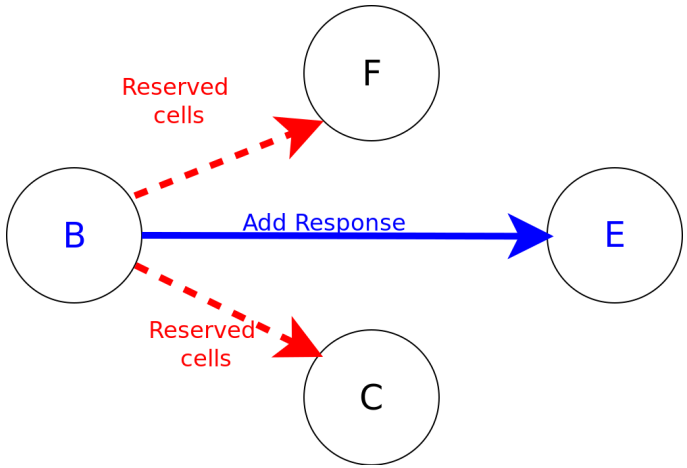
Using 6top Transaction

Why?

- Submitted in the shared slot.
- Contains the reserved cells.

How?

- The child node Sends an Add Request.
- The parent replies with the selected cells.



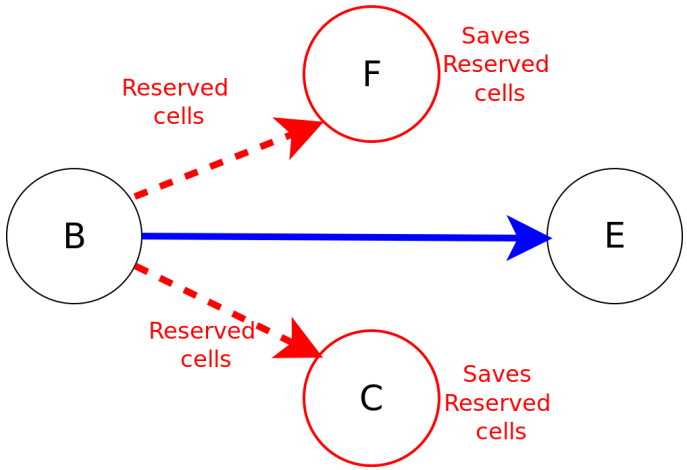
Using 6top Transaction

Why?

- Submitted in the shared slot.
- Contains the reserved cells.

How?

- The child node Sends an Add Request.
- The parent replies with the selected cells.
- The Neighbor nodes collects the reserved cells and save them.

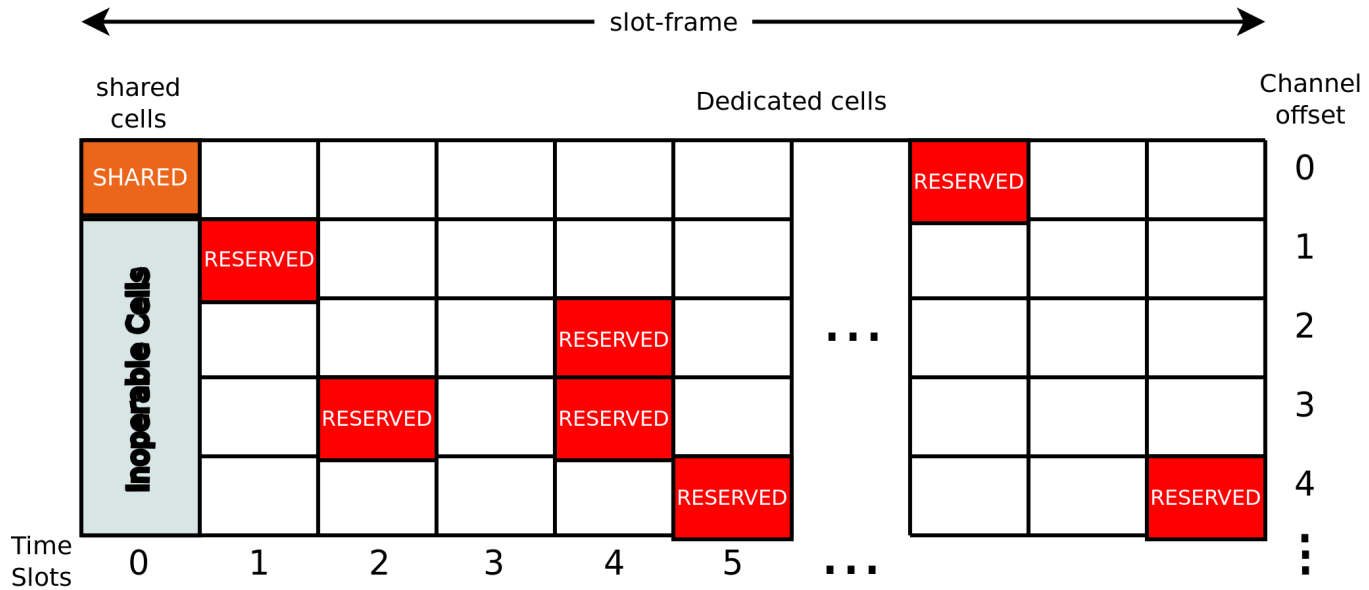


Outline

Avoid Table structure and functioning

Avoid Table

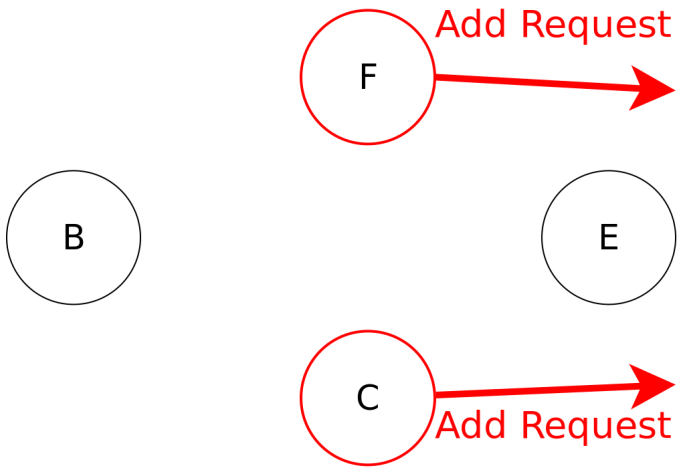
- The cells reserved by neighbors will be saved by a structure similar to TSCH table.



Avoid Table structure and functioning

Avoid Table

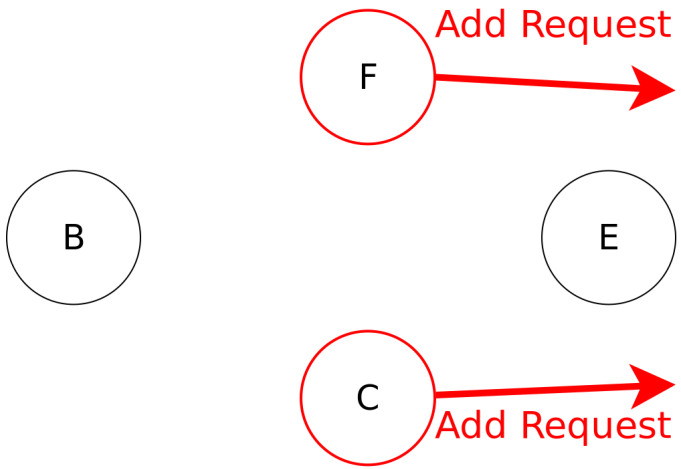
- The cells reserved by neighbors will be saved by a structure similar to TSCH table.
- Scheduling function will avoid selecting cells found in this structure.



Avoid Table structure and functioning

Avoid Table

- The cells reserved by neighbors will be saved by a structure similar to TSCH table.
- Scheduling function will avoid selecting cells found in this structure.
- 6top will manage this table.



Outline

Cell Buffer

Why?

- Some of the 6top Transaction are lost.

Cell Buffer

Why?

- Some of the 6top Transaction are lost.
- Number of the neighbors will not receive the reserved cells.

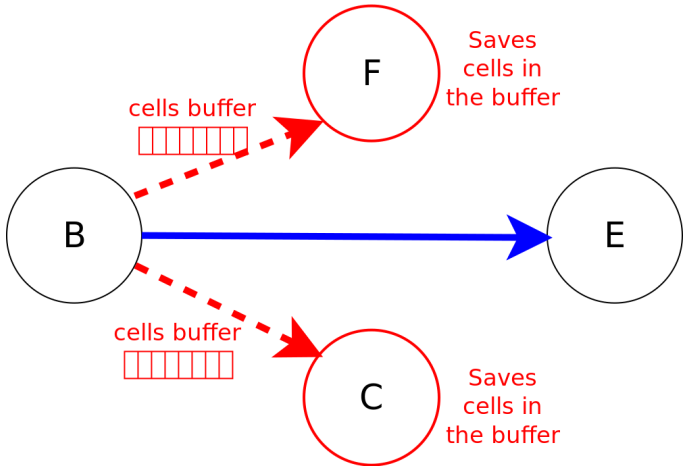
Cell Buffer

Why?

- Some of the 6top Transaction are lost.
- Number of the neighbors will not receive the reserved cells.

How?

- Creating a cell buffer of length k for each node.



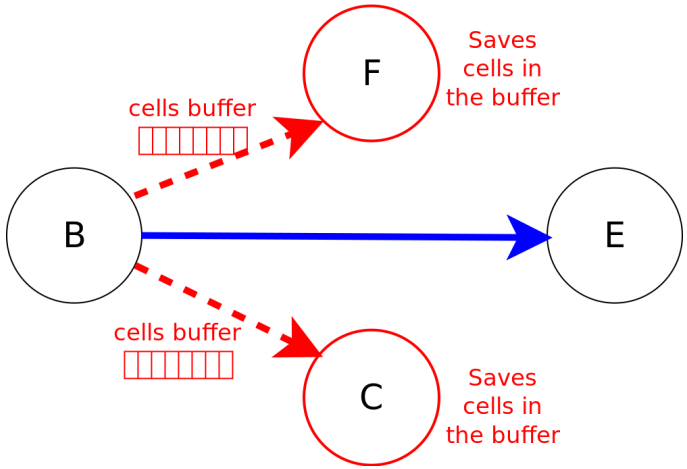
Cell Buffer

Why?

- Some of the 6top Transaction are lost.
- Number of the neighbors will not receive the reserved cells.

How?

- Creating a cell buffer of length k for each node.
- Transmitting the cell buffer each time a cell is reserved.



Outline

Simulator Architecture

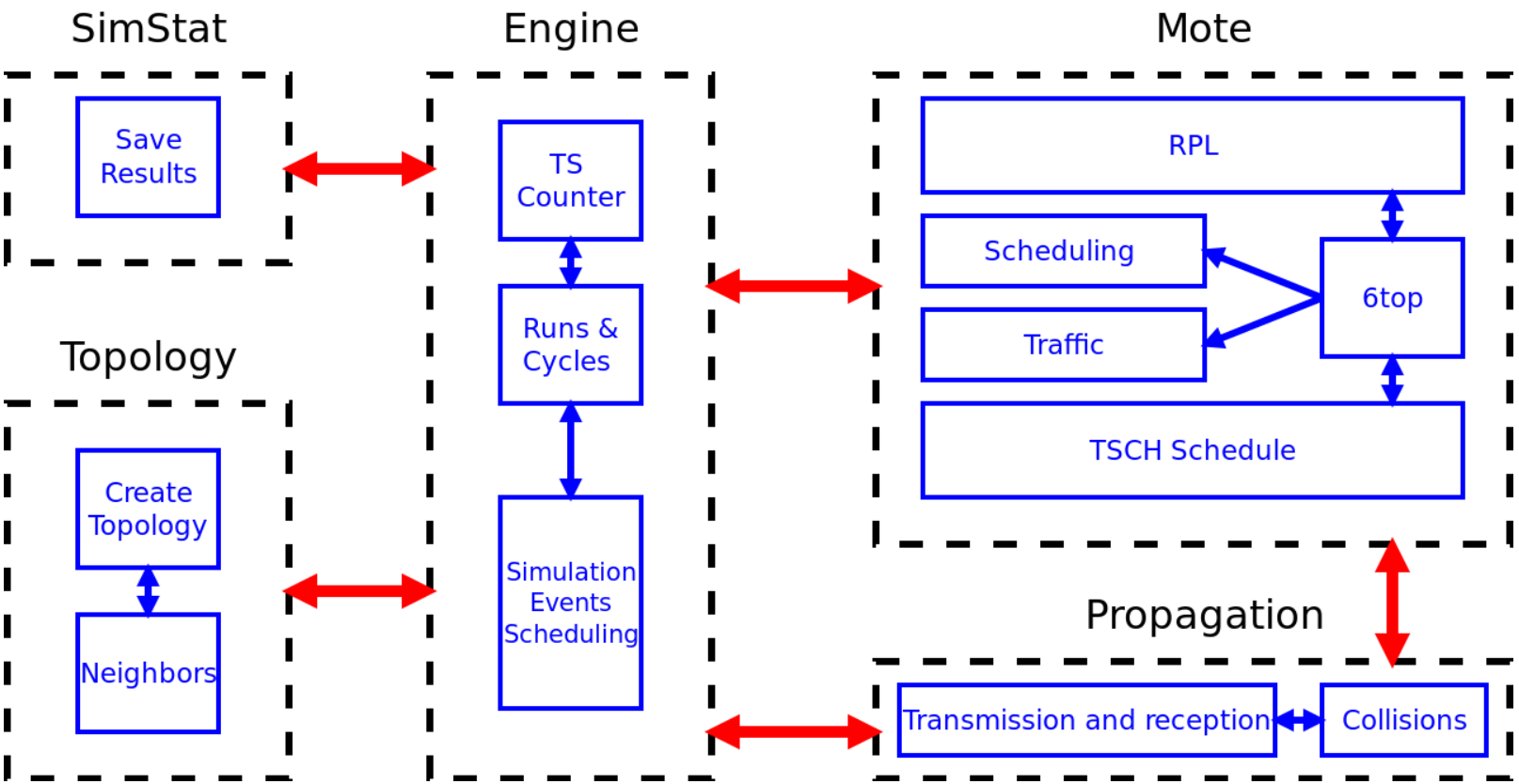


Figure: Simulator Architecture

Simulator Parameters

Parameter	Value
Number of Motes	100
Number of cycles per run	1000
Number of runs per simulation	1000
Timeslot duration	$10ms$
Slotframe length	101
Number of channels	16
Area	$1Km \times 1Km$
Topology constraint	$\geq$ 3 neighbors with PDR 50 %
Radio sensitivity	-97 dBm
Radio range	100m
Traffic	1 packet/node each 10 cycles

Outline

Results

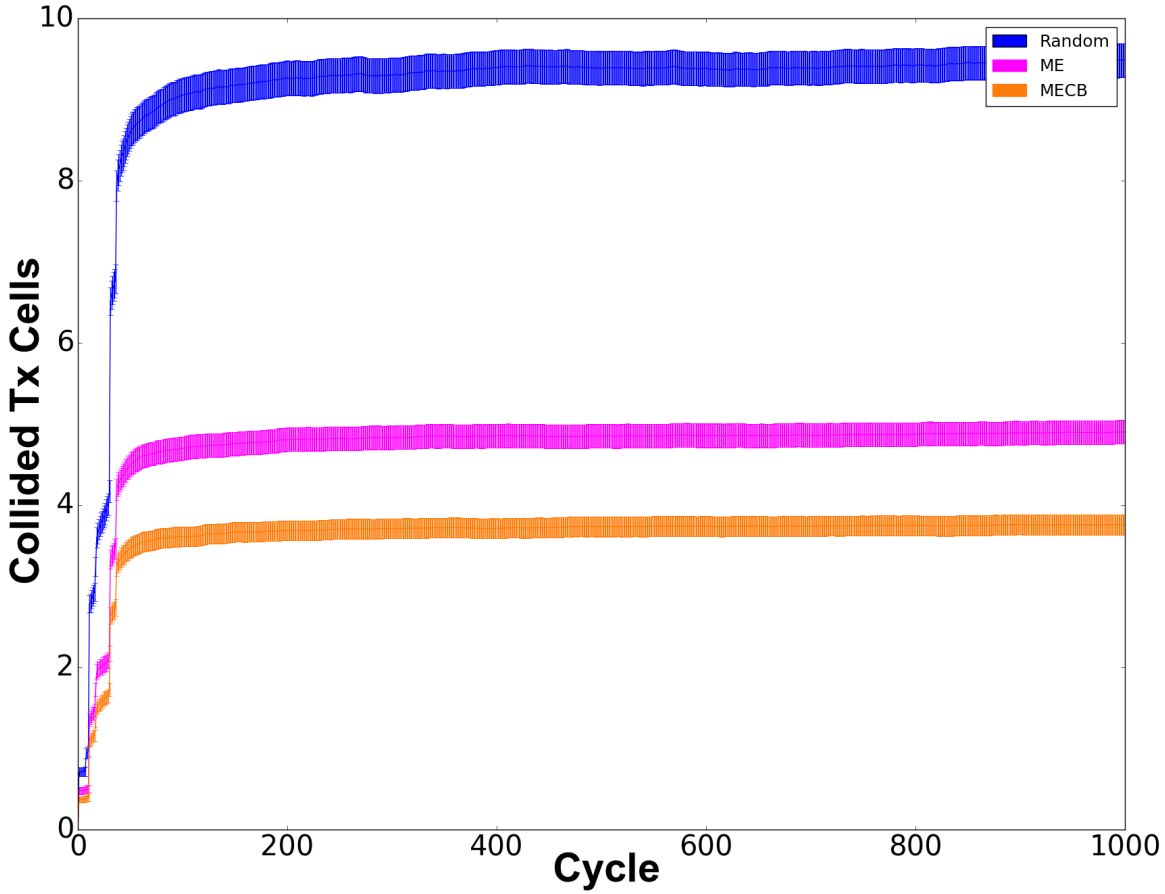


Figure: Simulation of the Number of Collided Tx Cells as Function of Cycle Number (Time)

Results

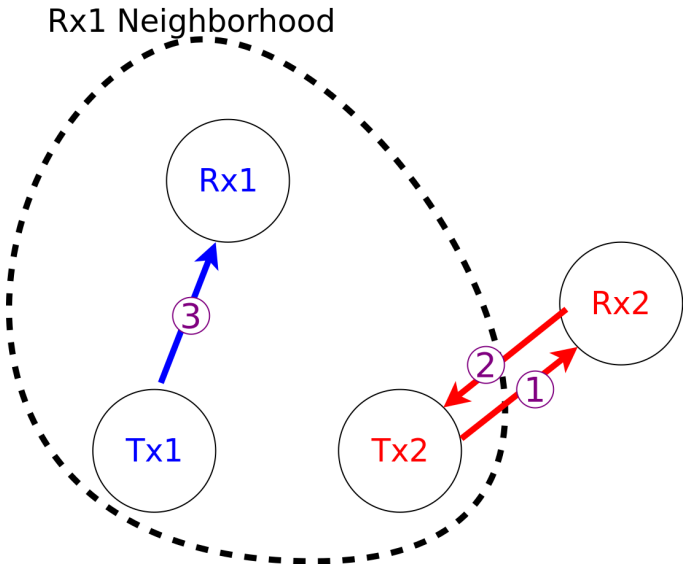
Collision reasons

- The lost 6top transactions.

Results

Collision reasons

- The lost 6top transactions.
- Special Case That Induce Collisions.



Comparison with Housekeeping

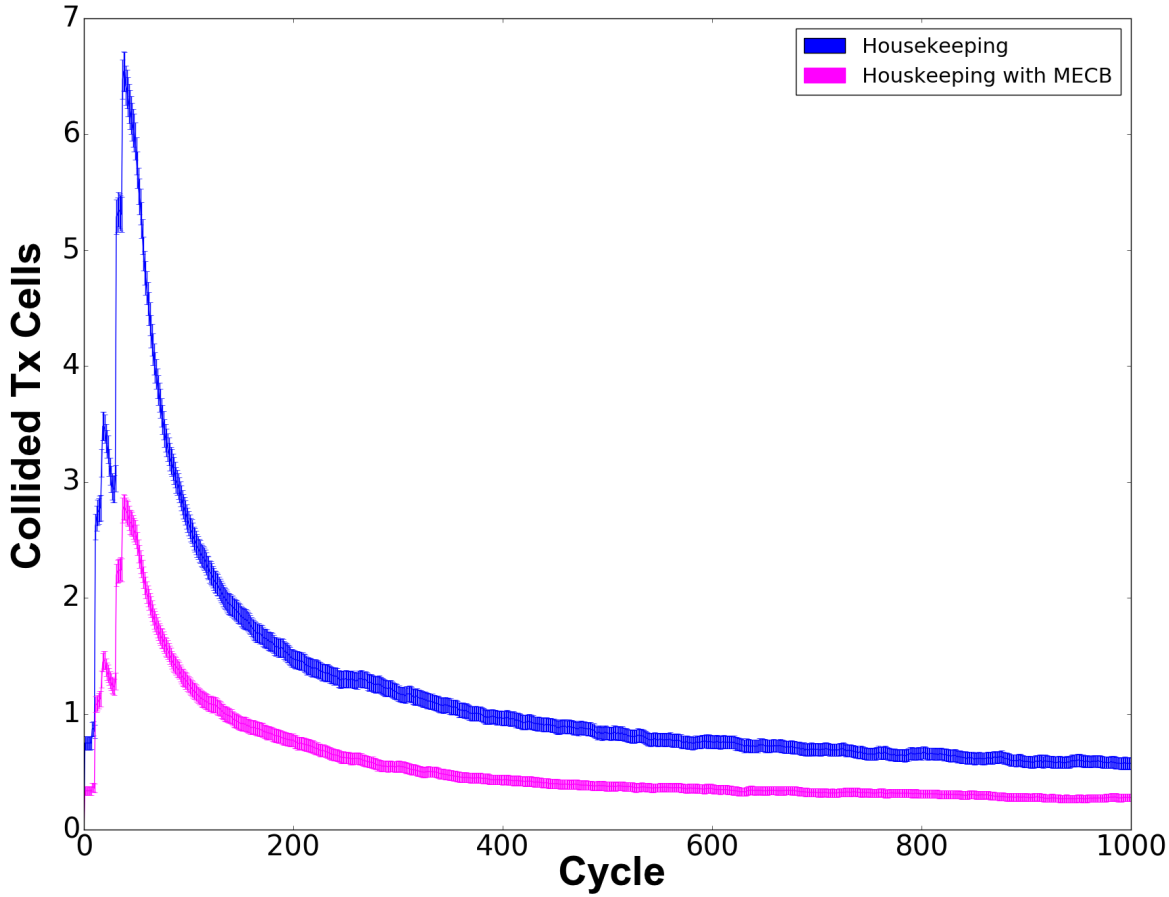


Figure: Simulation of the Number of Collided Tx Cells as Function of Cycle Number (Time) - comparison with the housekeeping approach

Summary

- Our implementation introduce no overhead in the network.
- The implementation achieved 60% reduction in the number of collided Tx cells and 70% reduction of the Collided Packets.
- The Combination of Our approach and Housekeeping accomplish an almost collision free dedicated cells.

- Outlook
  - Our goal is to reach a place were we have collision free network, using more complex methods.
  - Our prespective in this project was work on 6top, but our next steps is to study the effects of traffic in the protocols performances.