

# Collision Prevention in Distributed 6TiSCH Networks

Ali Jawad Fahs

Université Grenoble Alpes (UGA) - UFR IM<sup>2</sup>AG  
Laboratoire d'Informatique de Grenoble (LIG), Team Drakkar  
VERIMAG, Synchronic  
Supervised by : Olivier Alphand, Franck Rousseau  
Karine Altisen, Stéphane Devismes

Master thesis, 21<sup>st</sup> of June, 2017



# Outline

## Introduction & Background

- General Introduction

- IEEE802.15.4 Protocols

- Project challenges & Objectives

## Proposed Mechanism

- Using 6top Transaction

- Avoid Table

- Cell Buffer

## Simulator and Results

- Simulator

- Results

## Summary and Contributions

# Outline

## Introduction & Background

- General Introduction

- IEEE802.15.4 Protocols

- Project challenges & Objectives

## Proposed Mechanism

- Using 6top Transaction

- Avoid Table

- Cell Buffer

## Simulator and Results

- Simulator

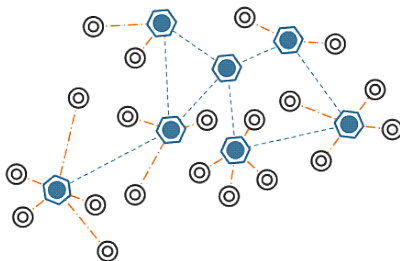
- Results

## Summary and Contributions

# General Introduction

## IoT & Wireless Sensor Networks

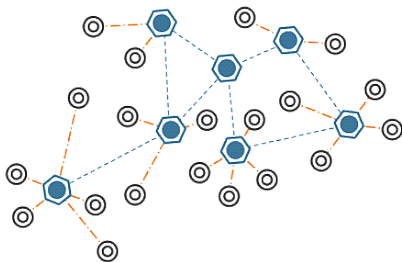
- ▶ Network technologies and IoT.



# General Introduction

## IoT & Wireless Sensor Networks

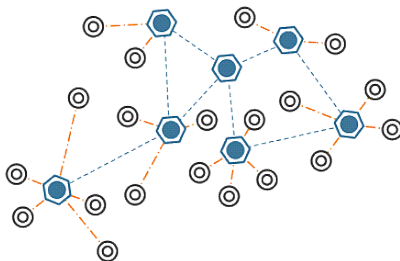
- ▶ Network technologies and IoT.
- ▶ WSN: standardization of IoT nodes communication.



# General Introduction

## IoT & Wireless Sensor Networks

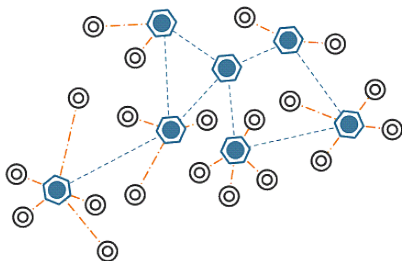
- ▶ Network technologies and IoT.
- ▶ WSN: standardization of IoT nodes communication.
- ▶ Low power consumption, low cost.



# General Introduction

## IoT & Wireless Sensor Networks

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

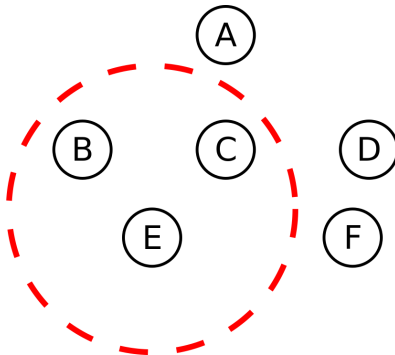


# General introduction

IEEE802.15.4

## Converge Cast Structure

- ▶ Nodes radio range defines the neighborhood.



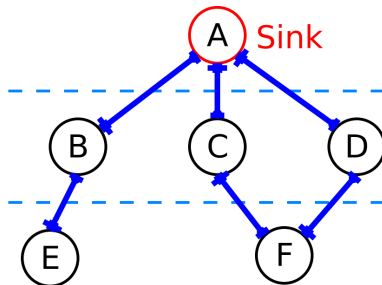


# General introduction

IEEE802.15.4

## Converge Cast Structure

- ▶ Nodes radio range defines the neighborhood.
- ▶ Sink is selected.

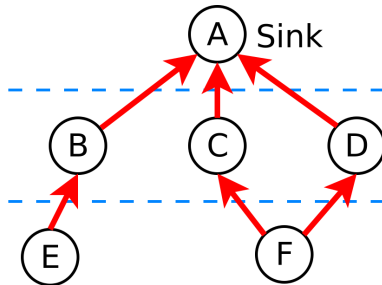


# General introduction

IEEE802.15.4

## Converge Cast Structure

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

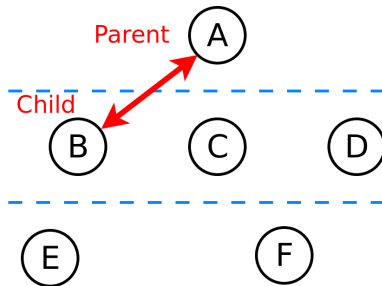


# General introduction

IEEE802.15.4

## Converge Cast Structure

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



# Outline

## Introduction & Background

General Introduction

IEEE802.15.4 Protocols

Project challenges & Objectives

## Proposed Mechanism

Using 6top Transaction

Avoid Table

Cell Buffer

## Simulator and Results

Simulator

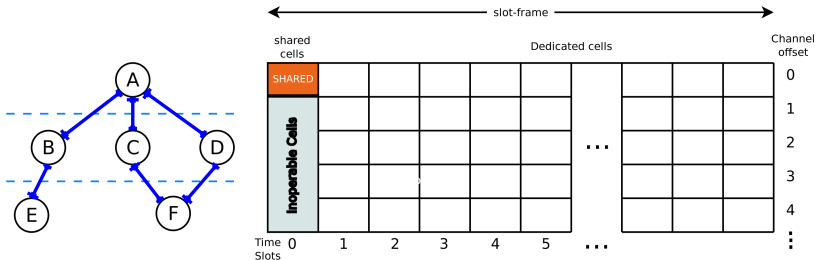
Results

## Summary and Contributions

# IEEE802.15.4 Protocols

## IEEE802.15.4e TSCH

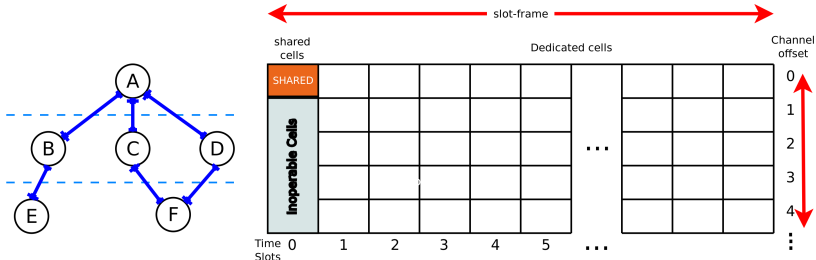
- ▶ IEEE802.15.4 defines the MAC and PHY layers.
- ▶ TSCH is an extension of the MAC layer of IEEE802.15.4.



# IEEE802.15.4 Protocols

## IEEE802.15.4e TSCH

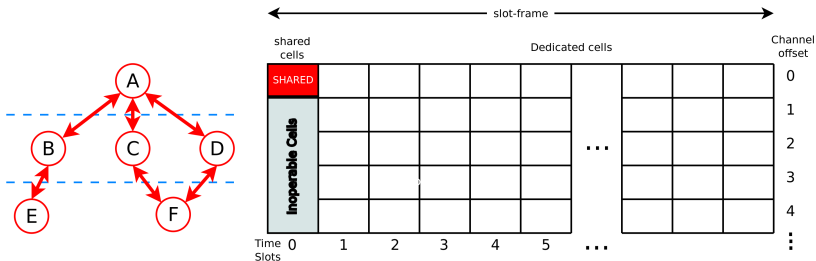
- ▶ IEEE802.15.4 defines the MAC and PHY layers.
- ▶ TSCH is an extension of the MAC layer of IEEE802.15.4.
- ▶ Time/Frequency multiplexing of the bandwidth.



# IEEE802.15.4 Protocols

## IEEE802.15.4e TSCH

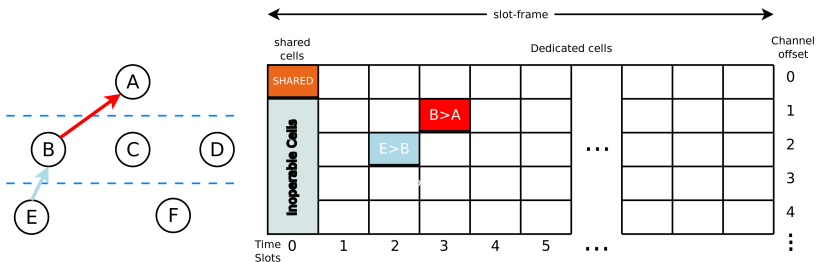
- ▶ IEEE802.15.4 defines the MAC and PHY layers.
- ▶ TSCH is an extension of the MAC layer of IEEE802.15.4.
- ▶ Time/Frequency multiplexing of the bandwidth.
- ▶ Shared cells/Dedicated cells..



# 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..



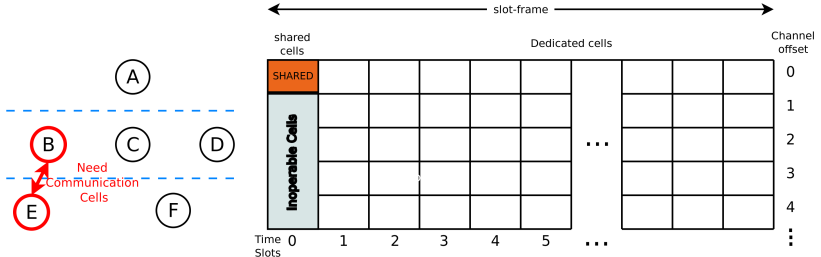




# IEEE802.15.4 Protocols

## Cell Reservation Process

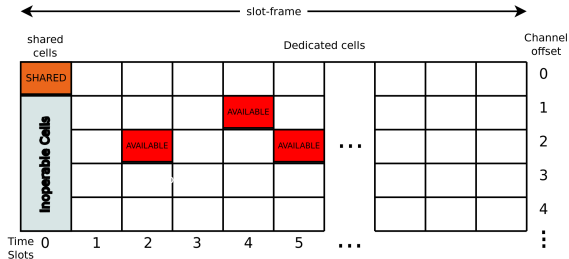
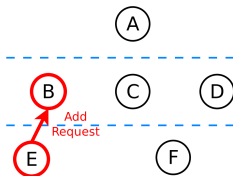
1. Scheduling function decides new cell should be assigned.



# IEEE802.15.4 Protocols

## Cell Reservation Process

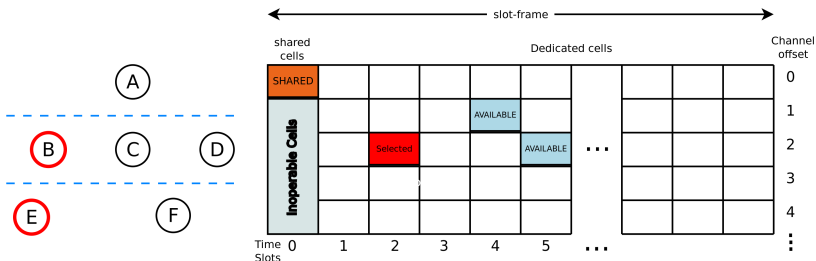
1. Scheduling function decides new cell should be assigned.
2. Child node sends an Add request.



# IEEE802.15.4 Protocols

## Cell Reservation Process

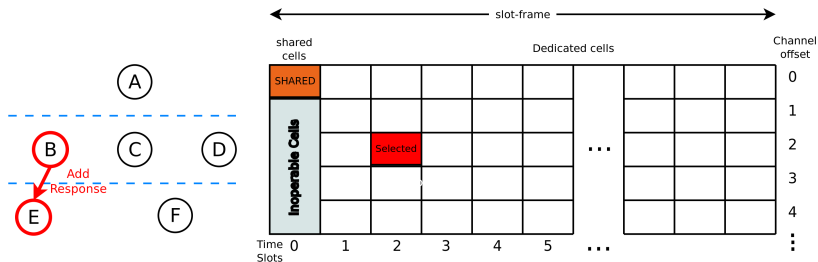
1. Scheduling function decides new cell should be assigned.
2. Child node sends an Add request.
3. Scheduling function decides which cells to be selected.



# IEEE802.15.4 Protocols

## Cell Reservation Process

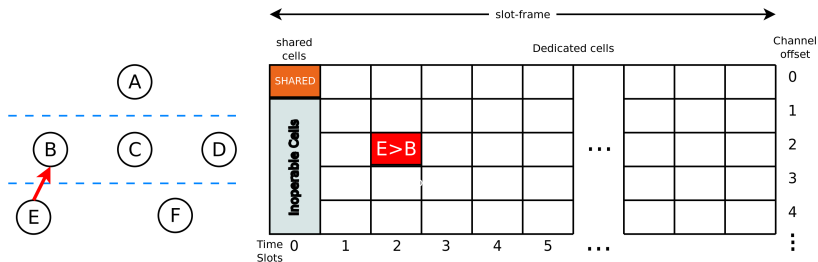
1. Scheduling function decides new cell should be assigned.
2. Child node sends an Add request.
3. Scheduling function decides which cells to be selected.
4. Parent node replies with an Add response.



# IEEE802.15.4 Protocols

## Cell Reservation Process

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



# Outline

## Introduction & Background

- General Introduction

- IEEE802.15.4 Protocols

- Project challenges & Objectives

## Proposed Mechanism

- Using 6top Transaction

- Avoid Table

- Cell Buffer

## Simulator and Results

- Simulator

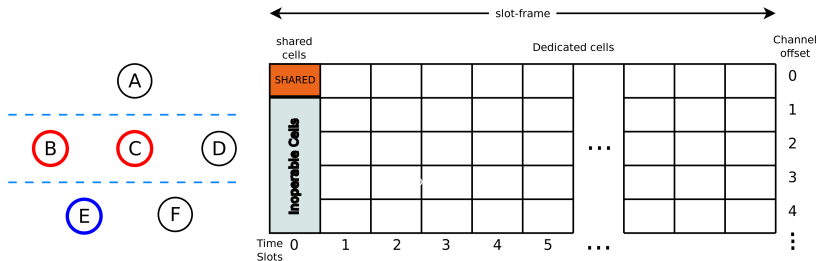
- Results

## Summary and Contributions

# Project challenges & Objectives

## Collision in Dedicated Cells

- ▶ Collision free Dedicated Cells?
- ▶ Neighbor nodes can select the same communication cell.

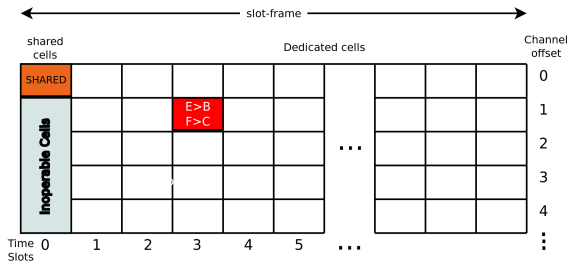
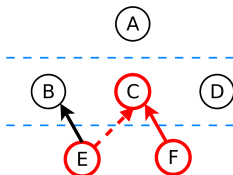




# Project challenges & Objectives

## Collision in Dedicated Cells

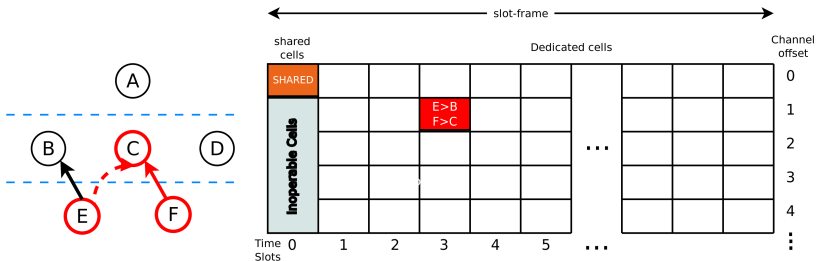
- ▶ Collision free Dedicated Cells?
- ▶ Neighbor nodes can select the same communication cell.



# Project challenges & Objectives

## Collision in Dedicated Cells

- ▶ Collision free Dedicated Cells?
- ▶ Neighbor nodes can select the same communication cell.
- ▶ Collision at the reception Node.



# 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

## Introduction & Background

General Introduction

IEEE802.15.4 Protocols

Project challenges & Objectives

## Proposed Mechanism

Using 6top Transaction

Avoid Table

Cell Buffer

## Simulator and Results

Simulator

Results

## Summary and Contributions

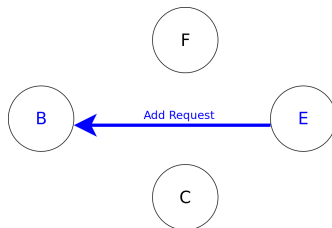
# Using 6top Transaction

## Why?

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

## How?

- ▶ The child node Sends an Add Request.



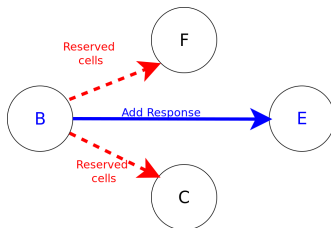
# Using 6top Transaction

## 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.





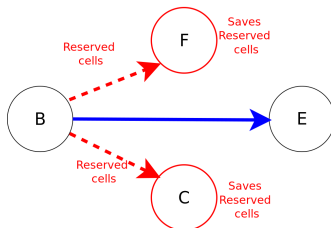
# Using 6top Transaction

## 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 collect the reserved cells and save them.



# Outline

## Introduction & Background

General Introduction

IEEE802.15.4 Protocols

Project challenges & Objectives

## Proposed Mechanism

Using 6top Transaction

Avoid Table

Cell Buffer

## Simulator and Results

Simulator

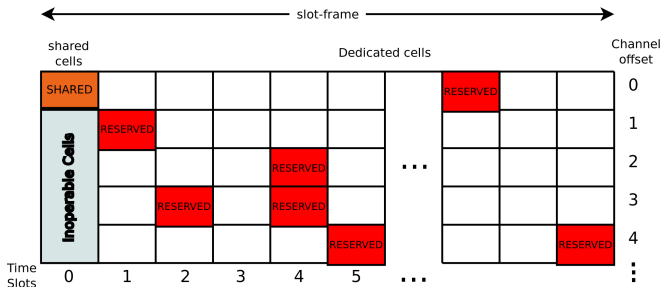
Results

## Summary and Contributions

# Avoid Table structure and functioning

## Avoid Table

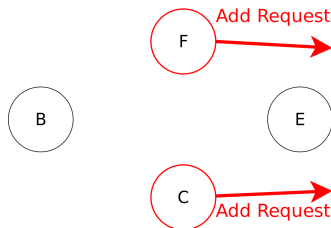
- ▶ The cells reserved by neighbors will be saved by a structure similar to TSCH table.



# Avoid Table structure and functioning

## Avoid Table

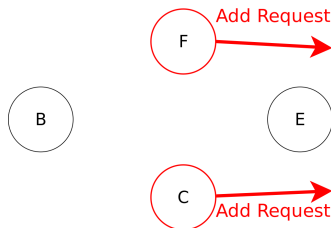
- ▶ The cells reserved by neighbors will be saved by a structure similar to TSCH table.
- ▶ Scheduling function will avoid selecting cells found in this structure.



# 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

## Introduction & Background

General Introduction

IEEE802.15.4 Protocols

Project challenges & Objectives

## Proposed Mechanism

Using 6top Transaction

Avoid Table

Cell Buffer

## Simulator and Results

Simulator

Results

## Summary and Contributions

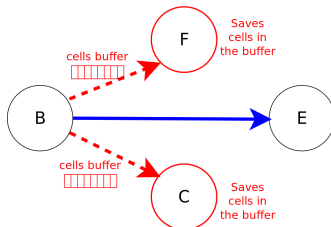
# Cell Buffer

## Why?

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

## How?

- ▶ Creating a cell buffer that will contain  $k$  reserved cells for each node.



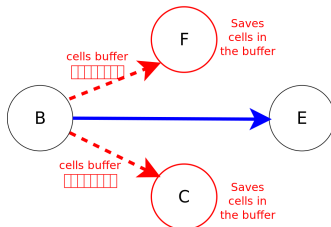
# Cell Buffer

## Why?

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

## How?

- ▶ Creating a cell buffer that will contain  $k$  reserved cells for each node.
- ▶ Transmitting the cell buffer each time a cell is reserved.





# Outline

## Introduction & Background

General Introduction

IEEE802.15.4 Protocols

Project challenges & Objectives

## Proposed Mechanism

Using 6top Transaction

Avoid Table

Cell Buffer

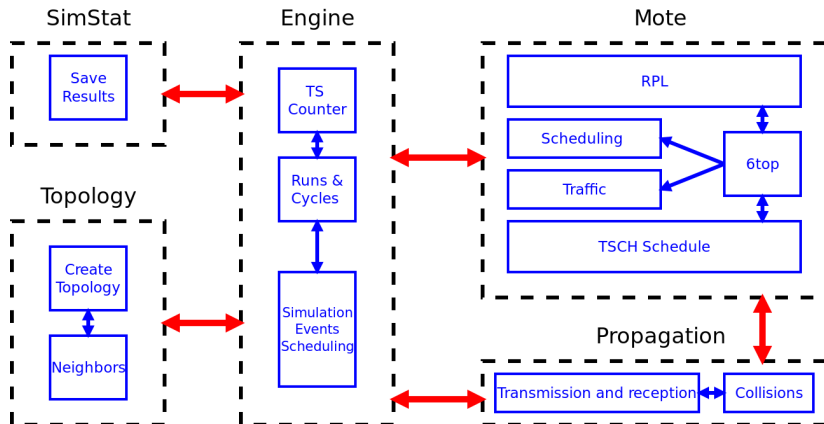
## Simulator and Results

Simulator

Results

## Summary and Contributions

# Simulator Architecture



# Simulation 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

## Introduction & Background

- General Introduction

- IEEE802.15.4 Protocols

- Project challenges & Objectives

## Proposed Mechanism

- Using 6top Transaction

- Avoid Table

- Cell Buffer

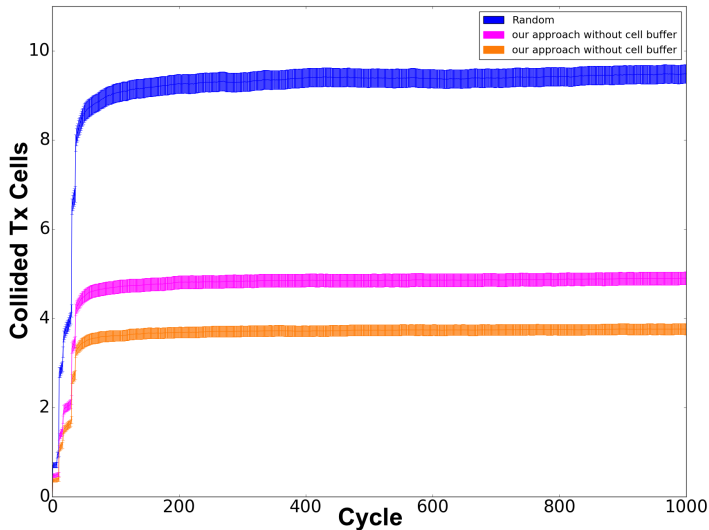
## Simulator and Results

- Simulator

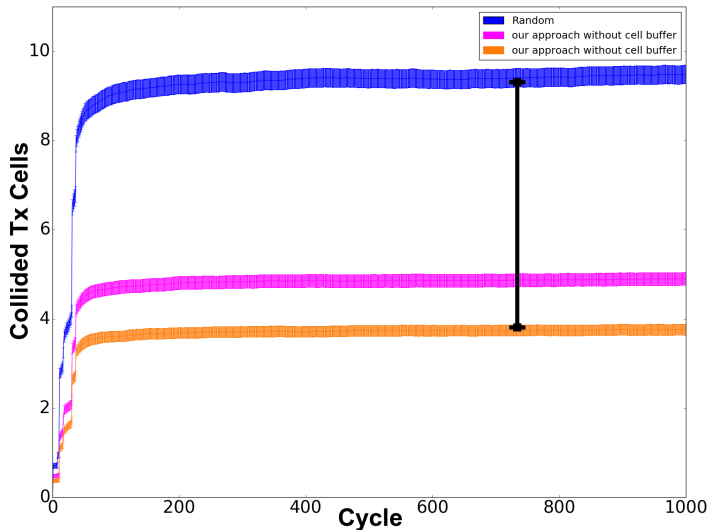
- Results

## Summary and Contributions

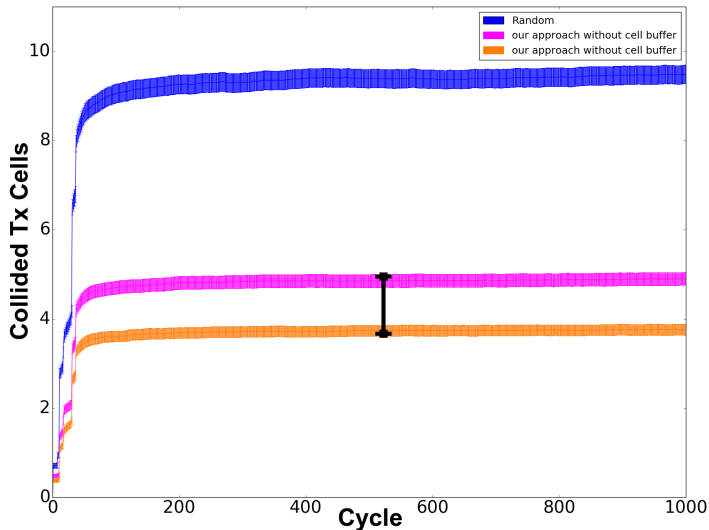
# Comparison with random scheduling



# Comparison with random scheduling



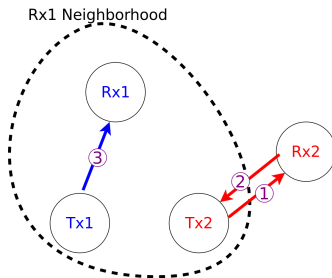
# Comparison with random scheduling



# Results

## Collision reasons

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

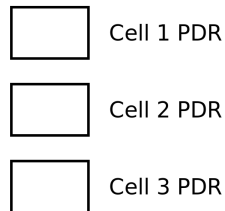




# Project challenges & Objectives

## Collision in Dedicated Cells

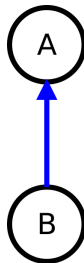
- ▶ Housekeeping approach and cell relocation.
- ▶ Tx housekeeping.



# Project challenges & Objectives

## Collision in Dedicated Cells

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



0.8

Cell 1 PDR

0.8

Cell 2 PDR

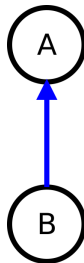
0.8

Cell 3 PDR

# Project challenges & Objectives

## Collision in Dedicated Cells

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



0.8

Cell 1 PDR

0.8

Cell 2 PDR

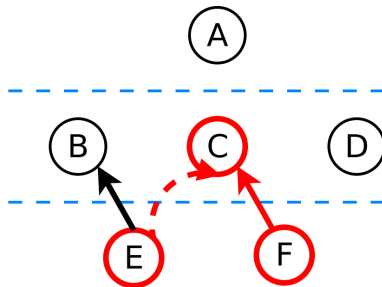
0.3

Cell 3 PDR

# Project challenges & Objectives

## Collision in Dedicated Cells

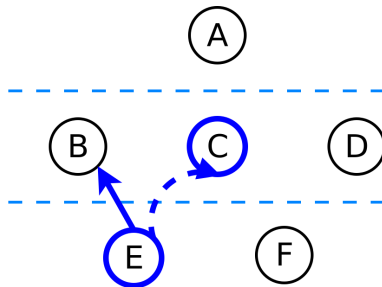
- ▶ Housekeeping approach and cell relocation.
- ▶ Tx housekeeping.
- ▶ Rx housekeeping.



# Project challenges & Objectives

## Collision in Dedicated Cells

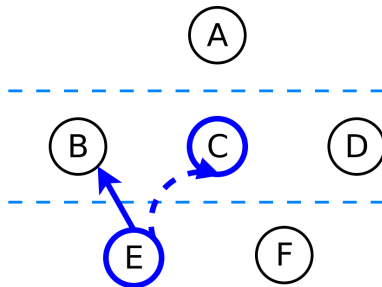
- ▶ Housekeeping approach and cell relocation.
- ▶ Tx housekeeping.
- ▶ Rx housekeeping.



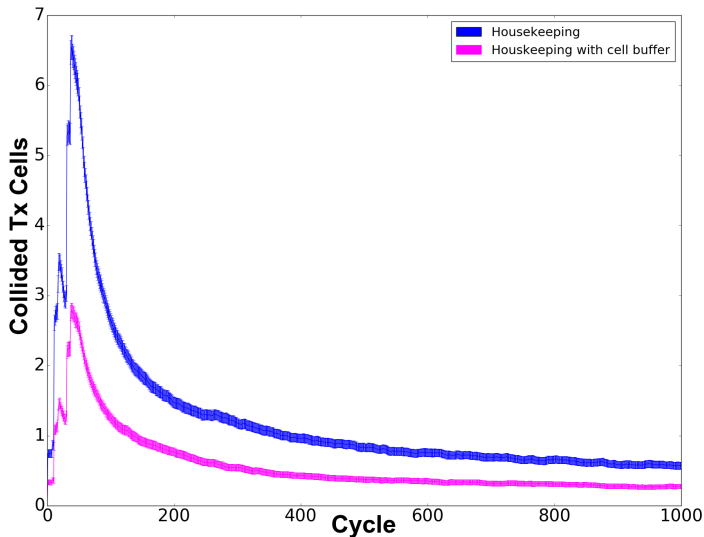
# Project challenges & Objectives

## Collision in Dedicated Cells

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



# Comparison with Housekeeping



# Summary

- ▶ Our implementation introduce **no overhead** in the network.
- ▶ The implementation **achieved 60% reduction** in the number of collided Tx cells.
- ▶ The Combination of Our approach and Housekeeping accomplish an **almost collision free dedicated cells**.
- ▶ Outlook
  - ▶ Our goal is to reach a place where we have collision free network, using more complex methods.
  - ▶ Our perspective in this project was work on 6top, but our next steps is to study the effects of traffic in the protocols performances.



## General introduction

### IEEE802.15.4

#### Converge Cast Structure

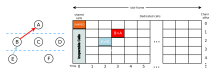
- Nodes radio ranges defines the neighborhood.
- Sink is selected.
- Packets are forwarded toward the sink.



## IEEE802.15.4 Protocols

### IEEE802.15.4e TSCH

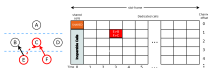
- IEEE802.15.4 defines the MAC and PHY layers.
- TSCH is an extension of the MAC layer of IEEE802.15.4.
- Time/Frequency multiplexing of the bandwidth.
- Shared cells.
- Dedicated cells.



## 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.



## 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 collect the reserved cells and save them.



## Simulator Architecture

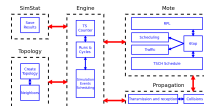


Figure: Simulator Architecture

## Comparison with Housekeeping

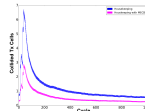


Figure: Simulation of the Number of Collided Tx Cells as Function of Cycle Number (Time) - comparison with the housekeeping approach

Thanks for your attention!  
Questions?