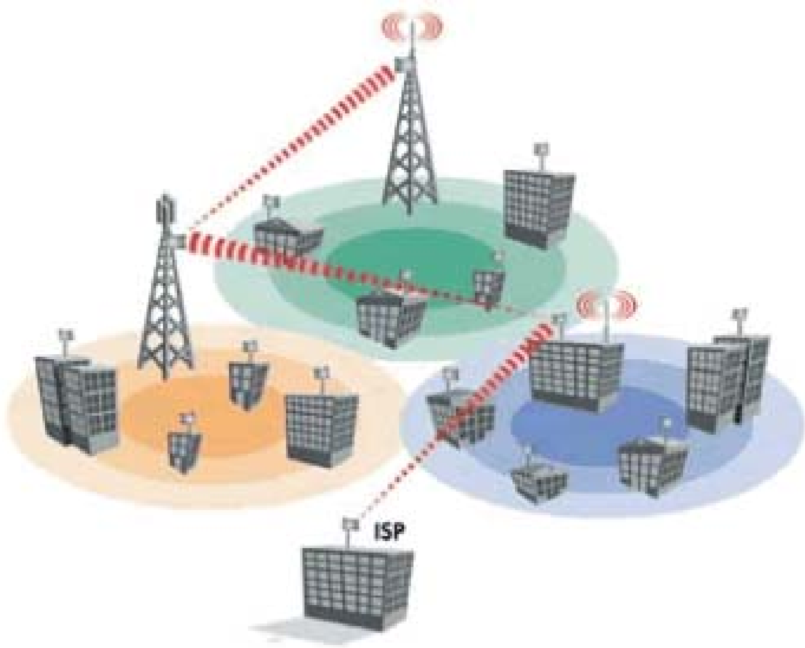

Attachment Learning for Multi-Channel Allocation in Distributed OFDMA Networks

Lu WANG

Computer Science and Engineering, HKUST

Dec 9, 2011

Roadmap

- Introduction
- Motivation
- AT-Learning Design
- Performance Evaluation
- Conclusion

Roadmap

- **Introduction**
- Motivation
- AT-Learning Design
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Introduction

1. Dense deployment of wireless devices
2. Crowded usage of limited wireless resource
3. Fine-grained channel access

OFDMA Paradigm

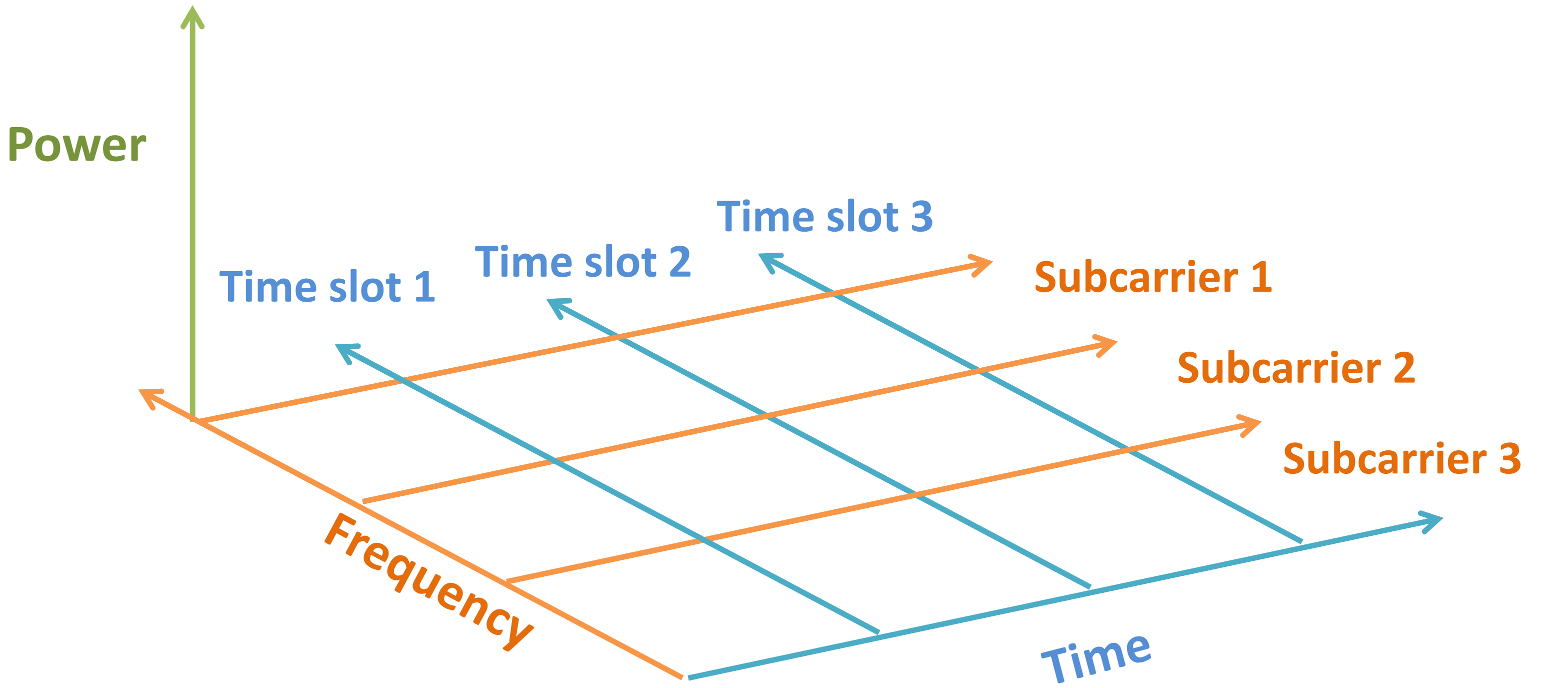
OFDMA

Orthogonal Frequency-Division Multiple Access

OFDMA Paradigm

OFDMA

Orthogonal Frequency-Division Multiple Access

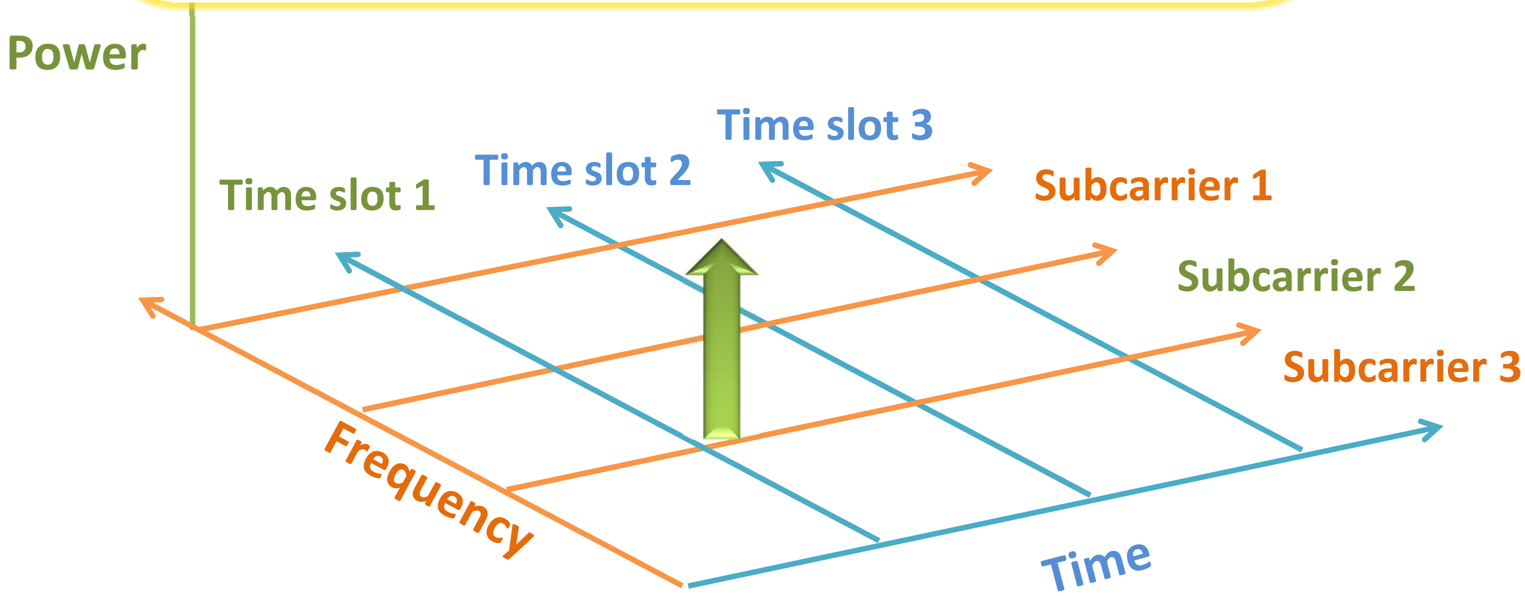


OFDMA Paradigm

OFDMA

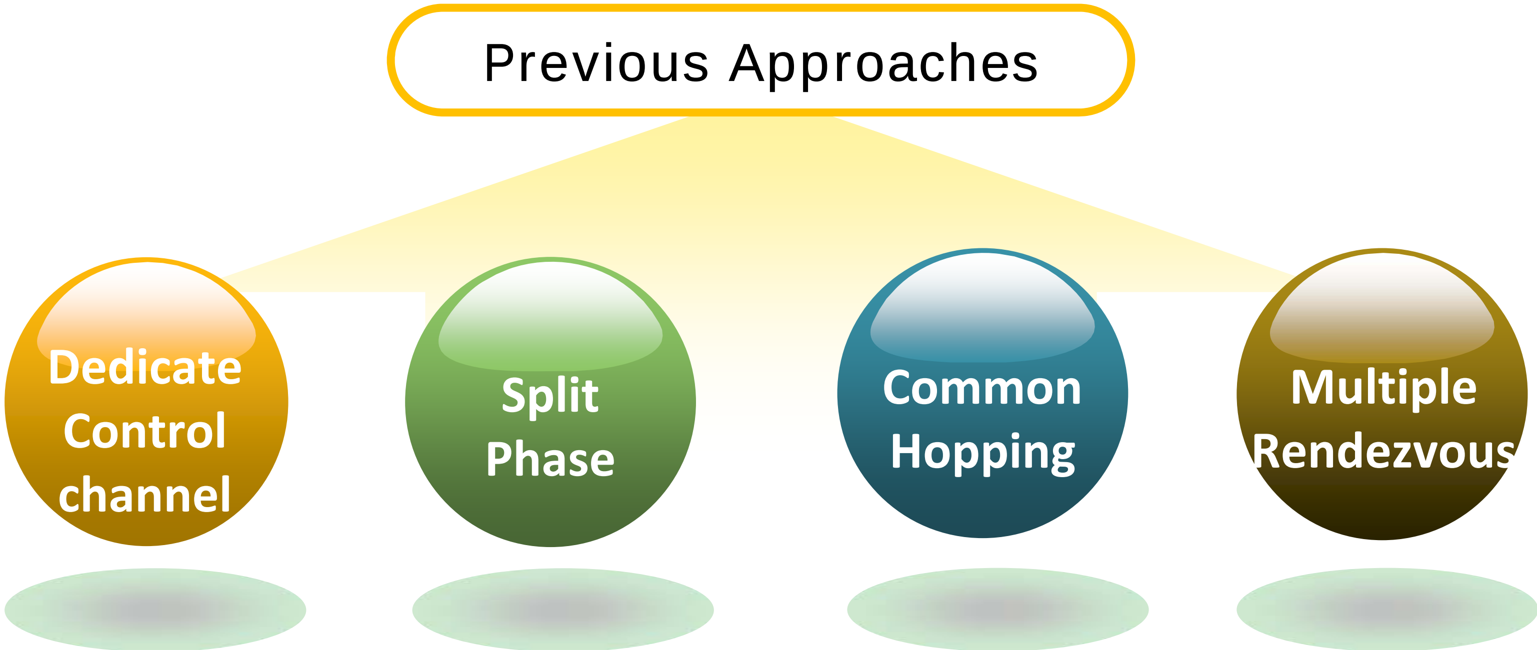
Orthogonal Frequency-Division Multiple Access

Contends for a certain subcarrier
in a certain time slot for transmission




Fine-grained channel access
Efficient multichannel allocation approach

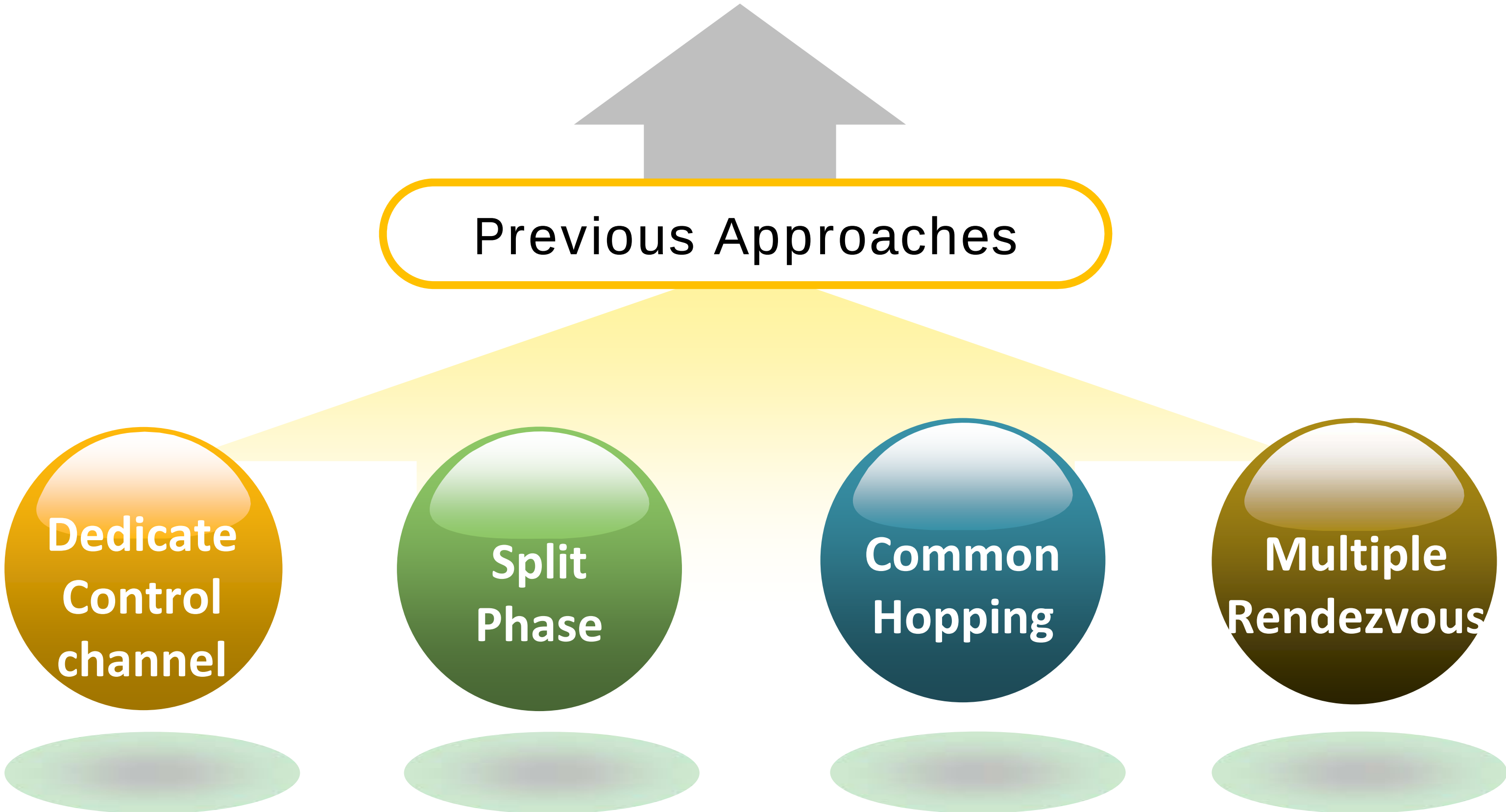
Previous Approaches



Previous Approaches

Costly Coordination →

Reduce the effective throughput of data traffic!



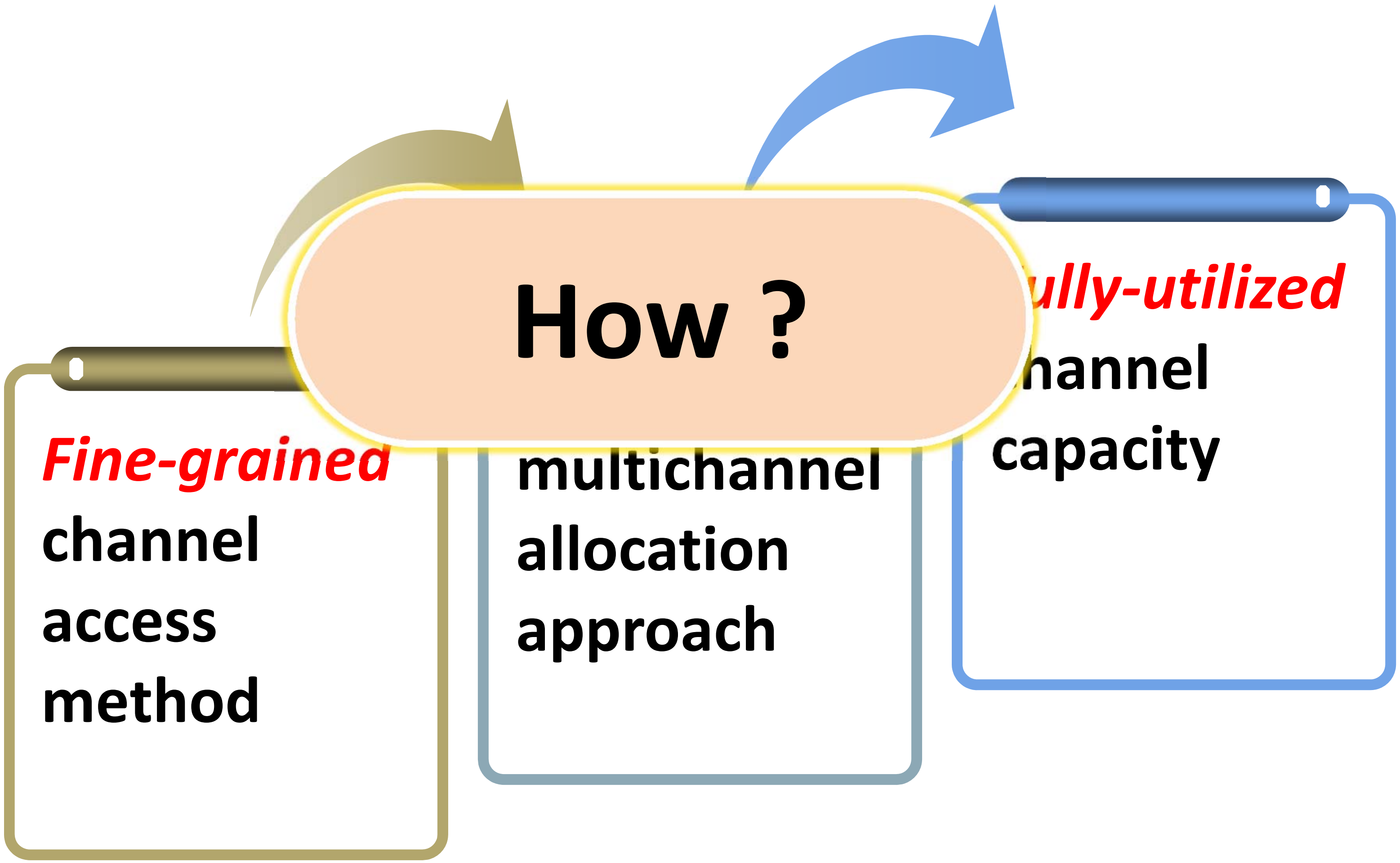
The Problem

Fine-grained **channel access method**

Cost-effective **multichannel allocation approach**

Fully-utilized **channel capacity**

The Problem


How ?
Fine-grained channel access method
multichannel allocation approach
ully-utilized hannel capacity

Roadmap

- ~~Introduction~~
- **Motivation**
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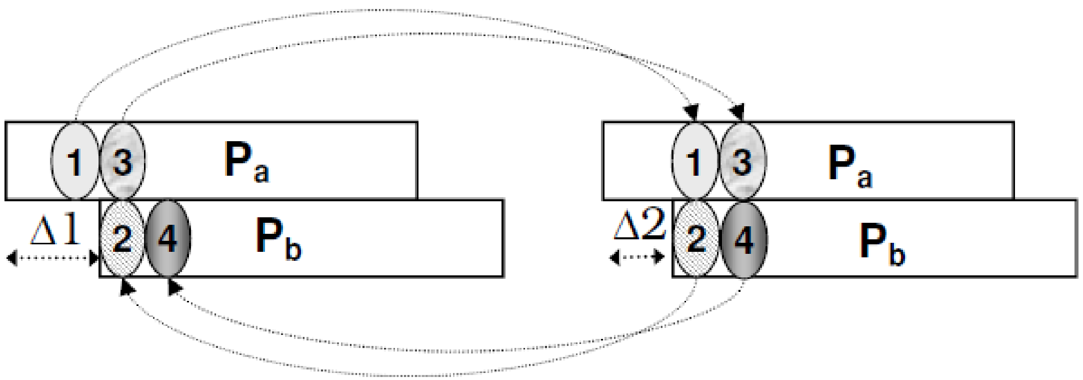
Observation 1/2

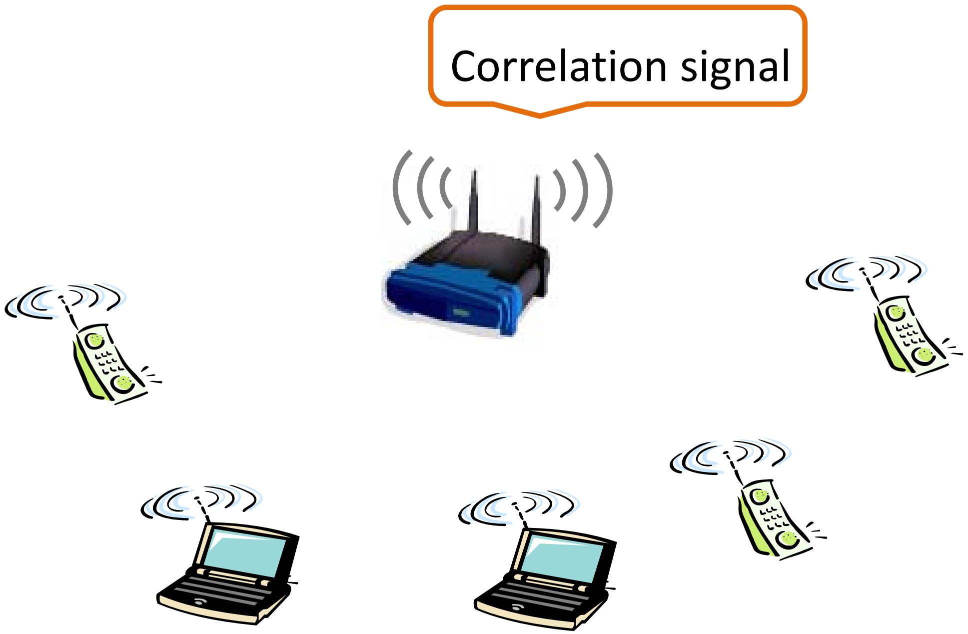
- Interference cancellation
  - ZigZag Decoding [*SIGCOMM'08*]
  - Using *interference-free* chunk of packet to *decoding the collided chunk* in an iterative way



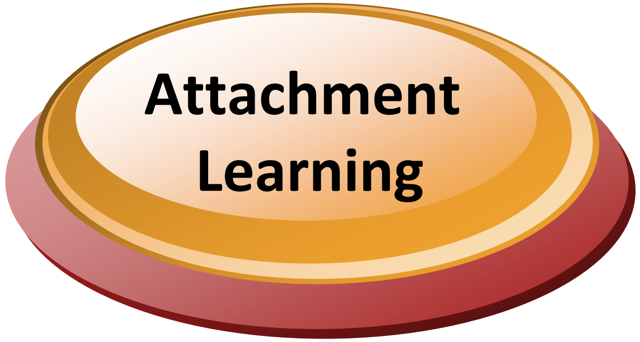
$\Delta 1 \neq \Delta 2$

Observation 2/2

- *Correlated Equilibrium* in Game theory
  - each player chooses his/her action according to the value of *a public correlation signal*



Motivation



Motivation

Attachment Learning

Observation 1

Interference cancellation

To provide cost-effective correlation signal

Motivation

Attachment Learning

Observation 1

Interference cancellation

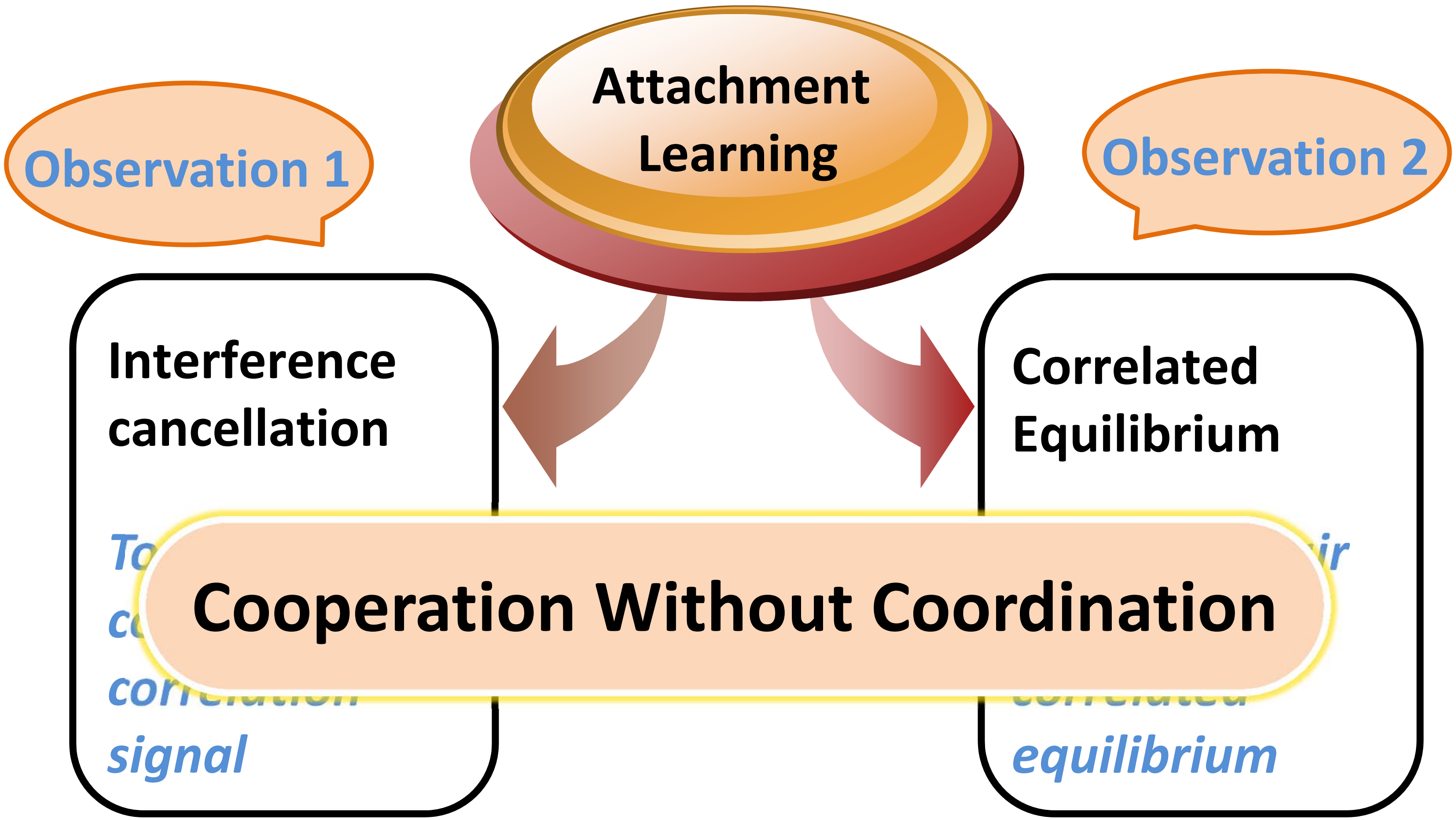
To provide cost-effective correlation signal

Observation 2

Correlated Equilibrium

To achieve fair allocation by correlated equilibrium

Motivation



Observation 1
Attachment Learning
Observation 2
Interference cancellation
Correlated Equilibrium
Cooperation Without Coordination
signal
equilibrium

Roadmap

- ~~Introduction~~
- ~~Motivation~~
- **AT-Learning Design**
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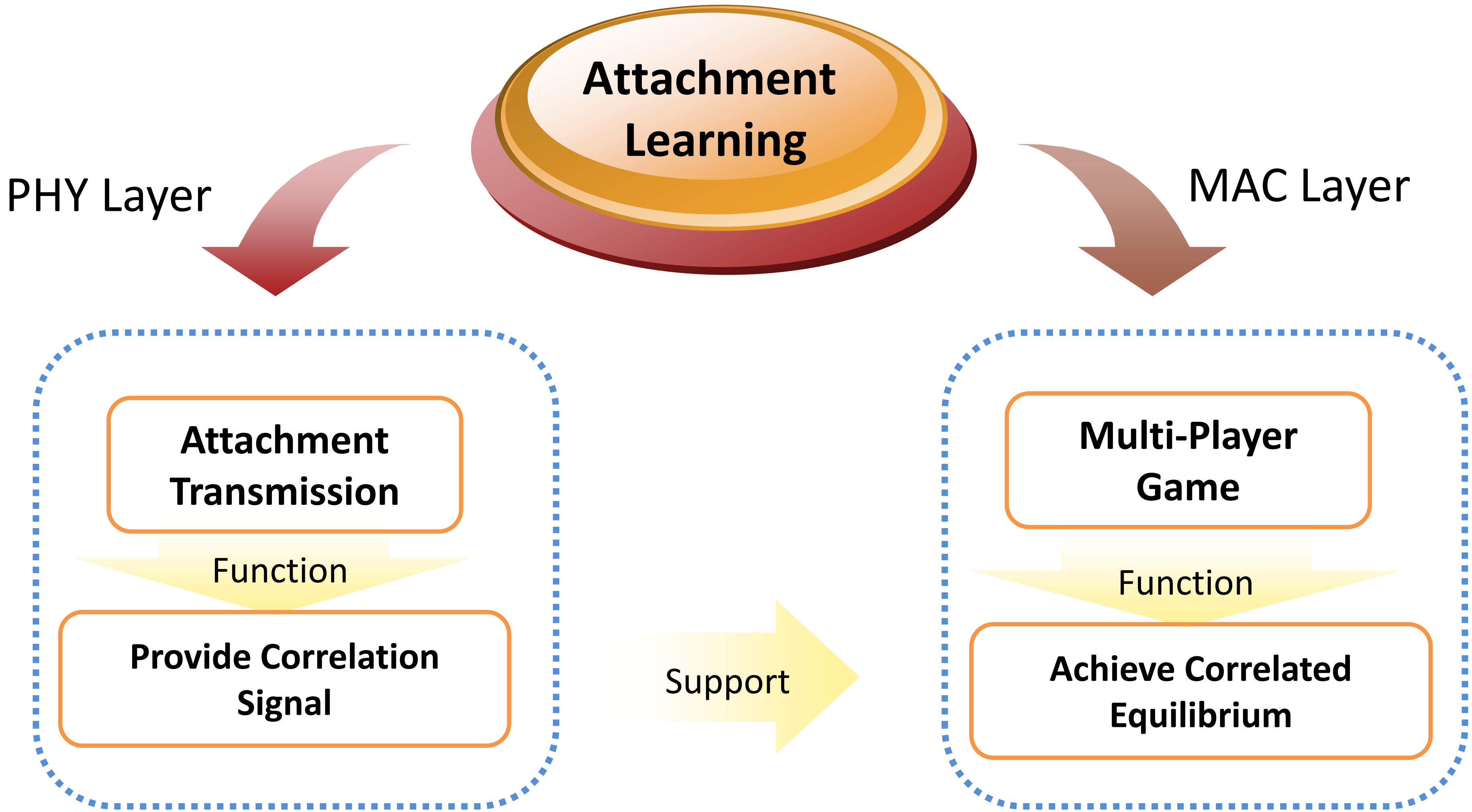
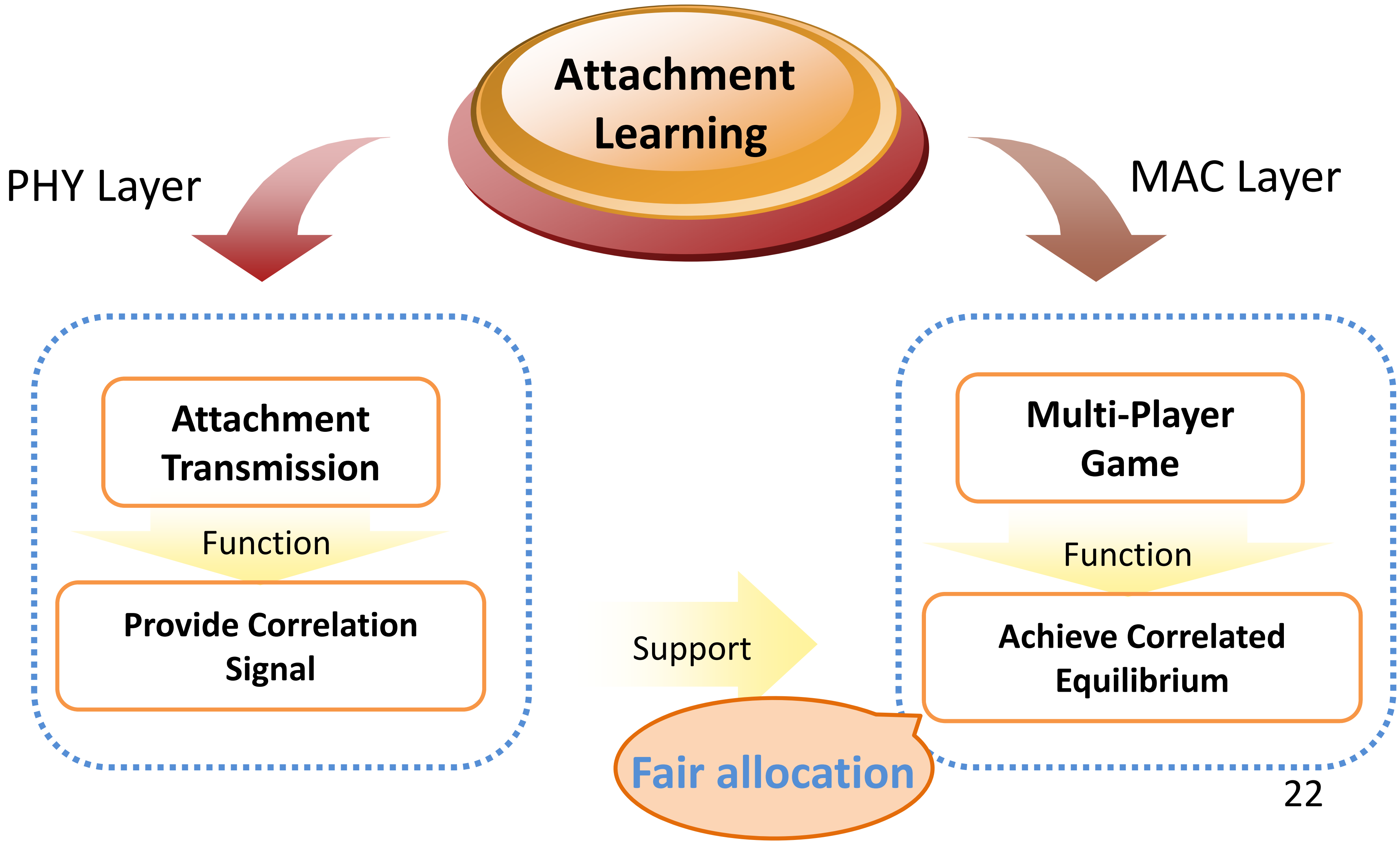
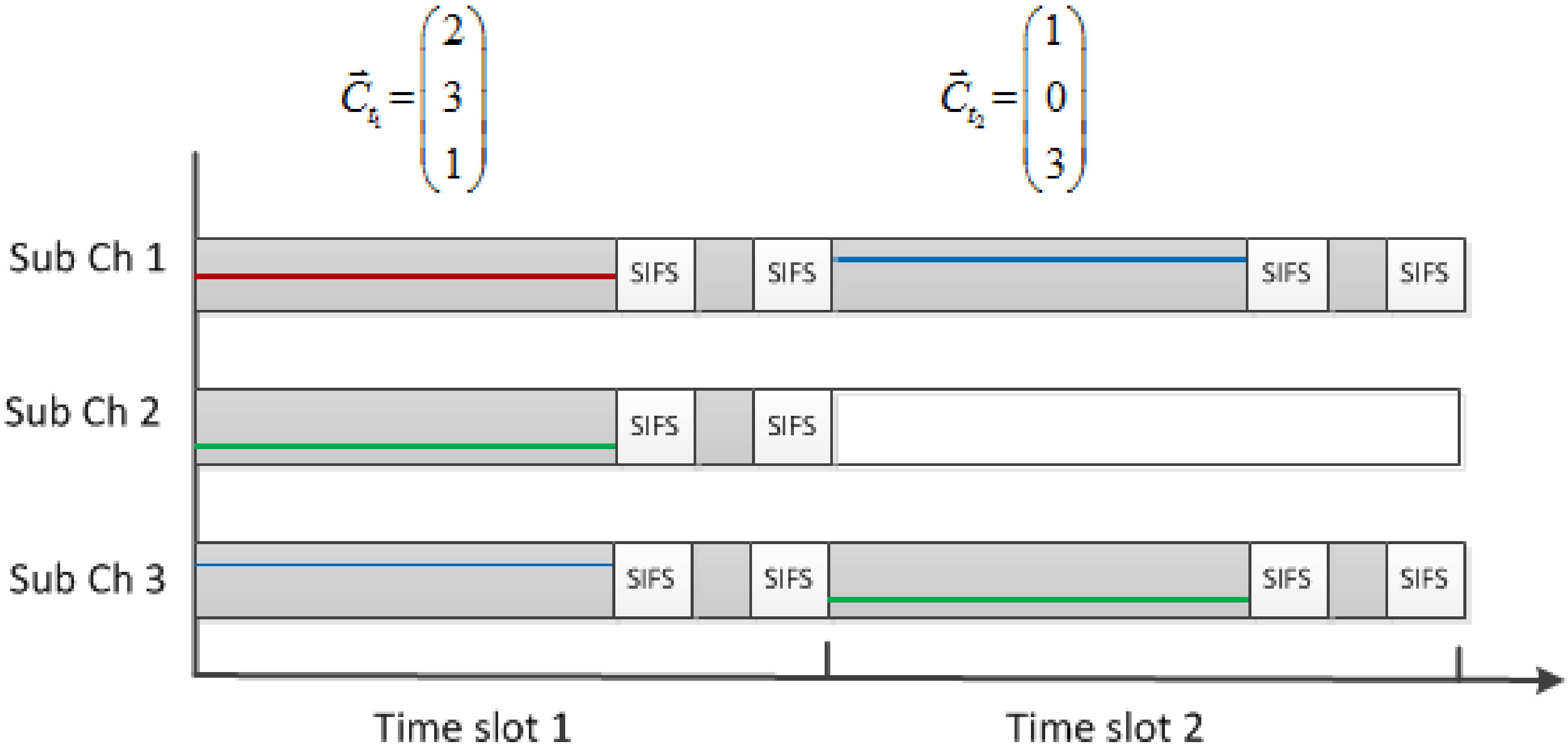
AT-Learning Architecture



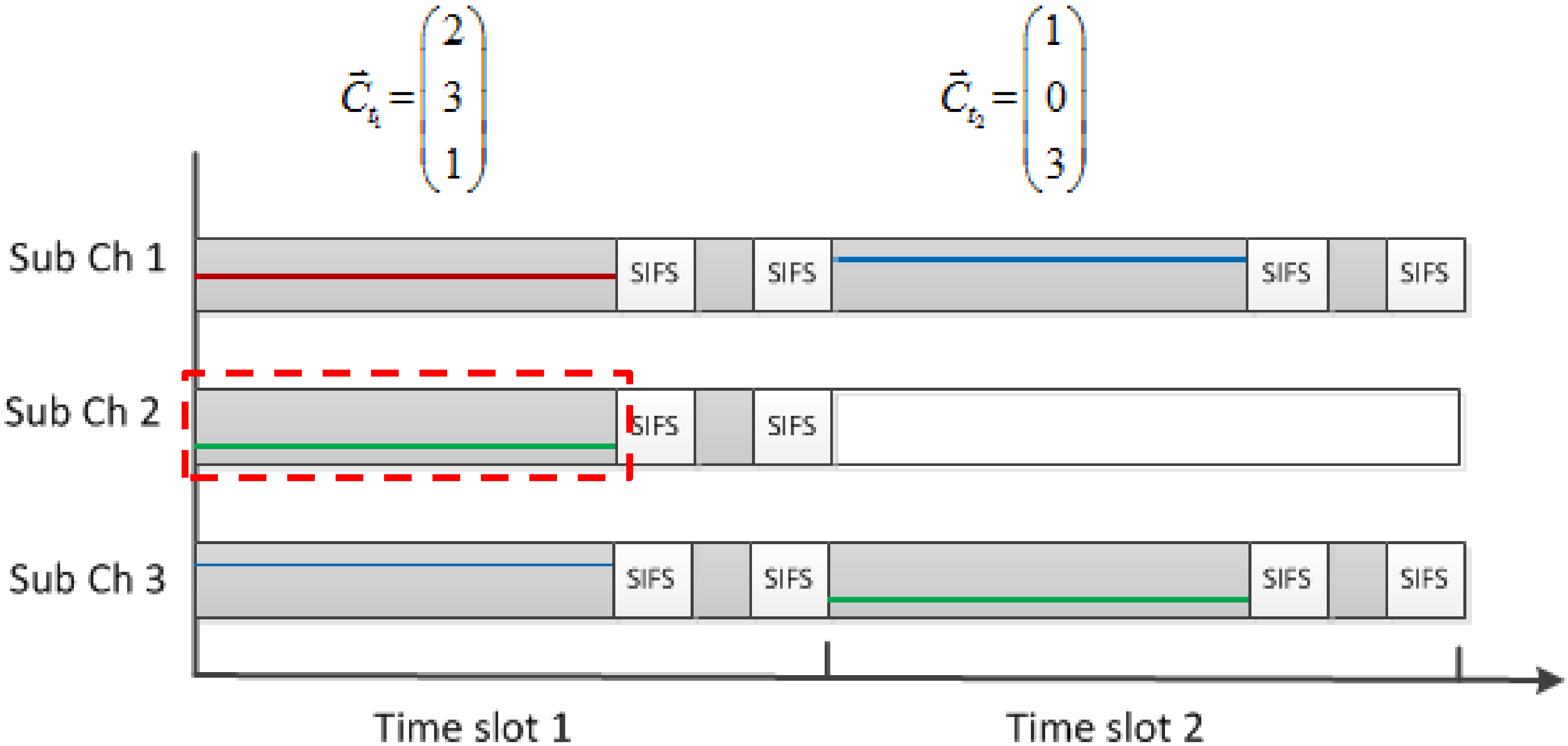
AT-Learning Architecture



AT-Learning Illustration



AT-Learning Illustration



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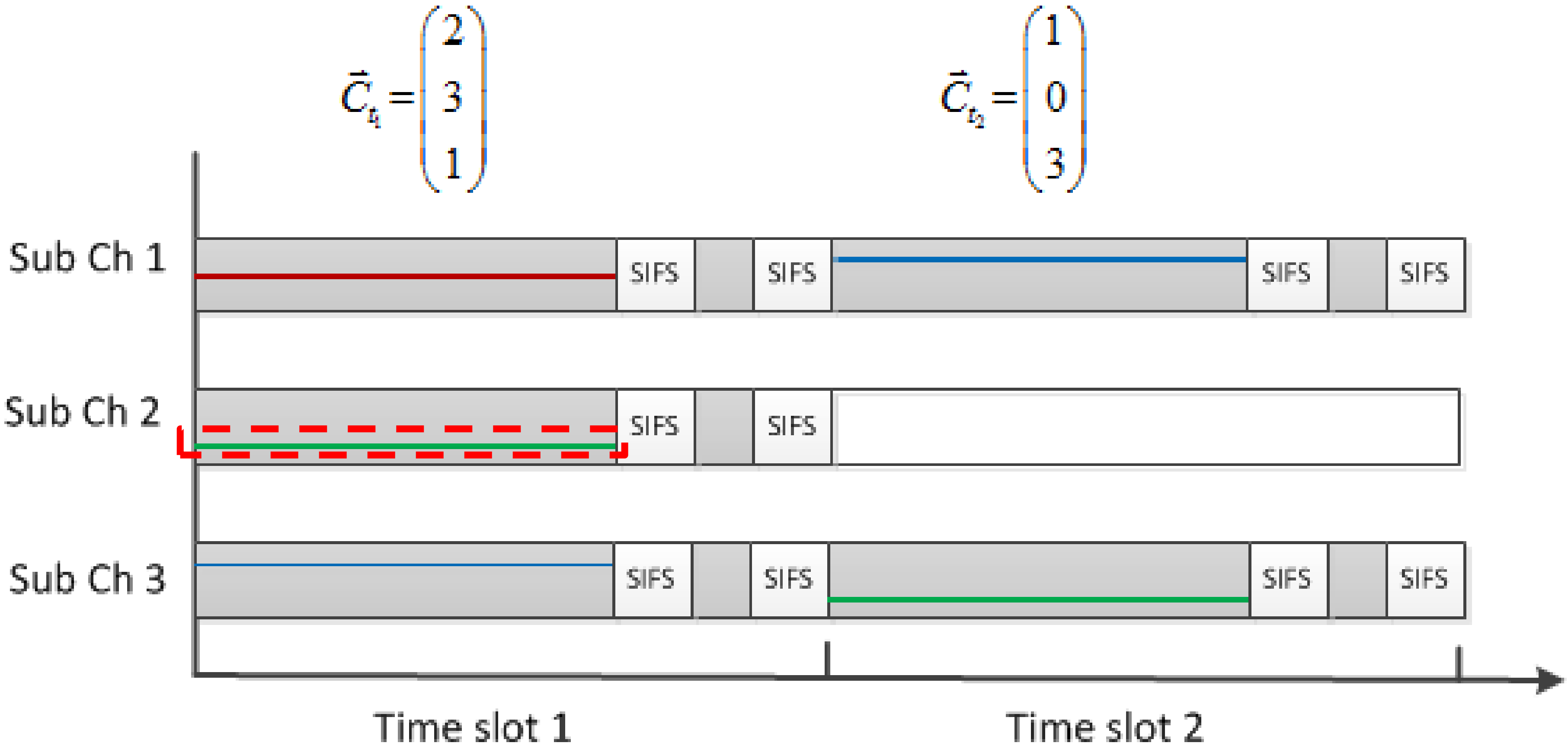
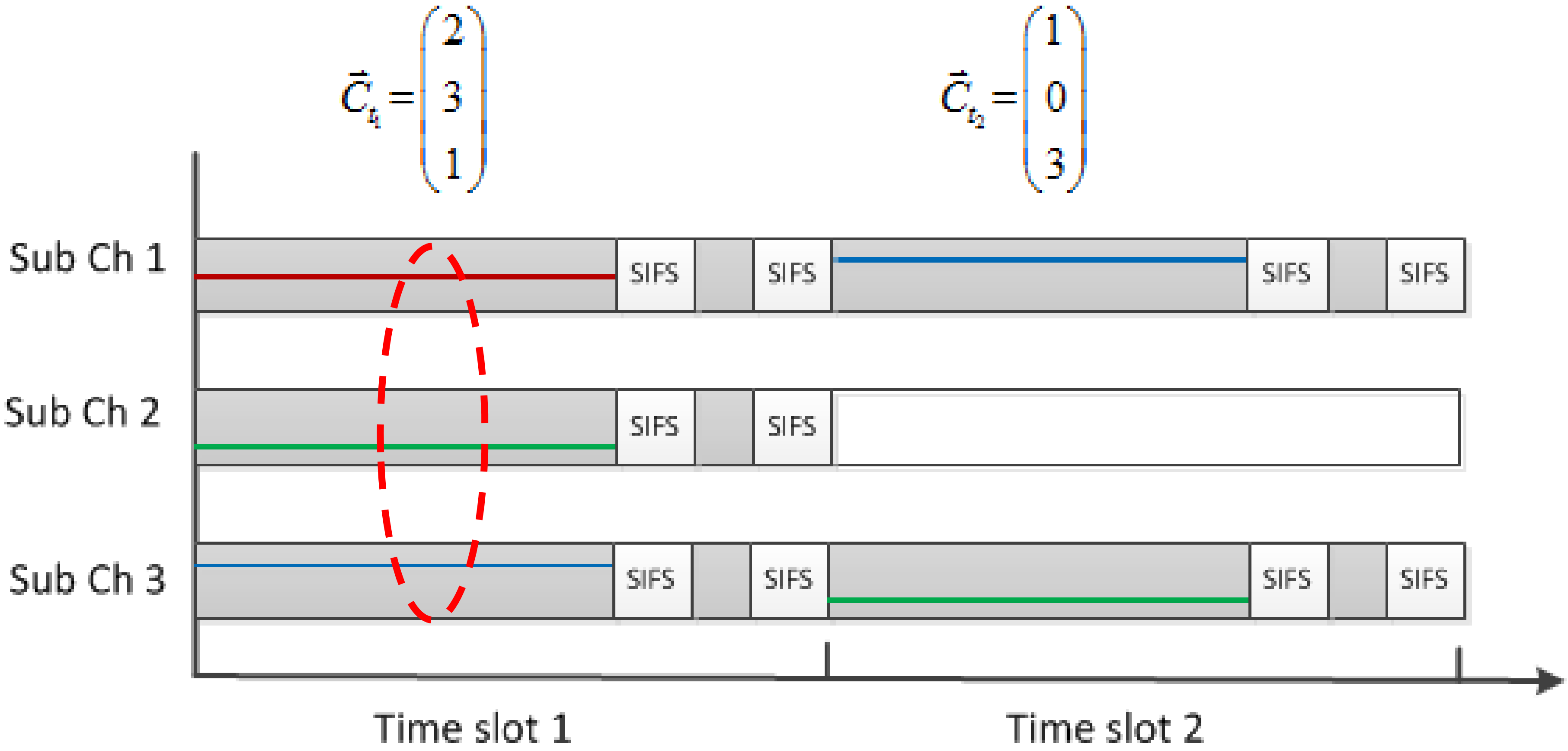
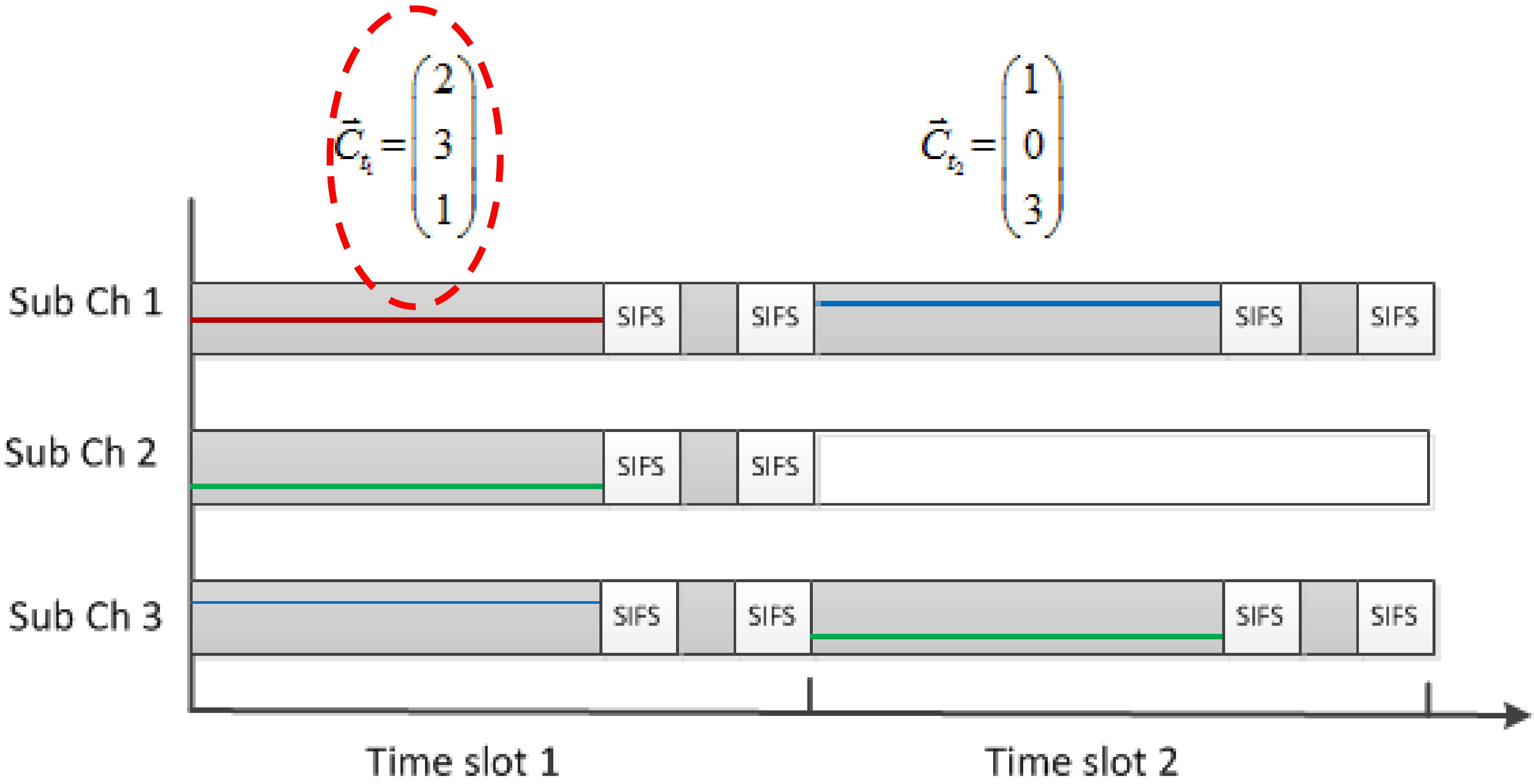


AT-Learning Illustration



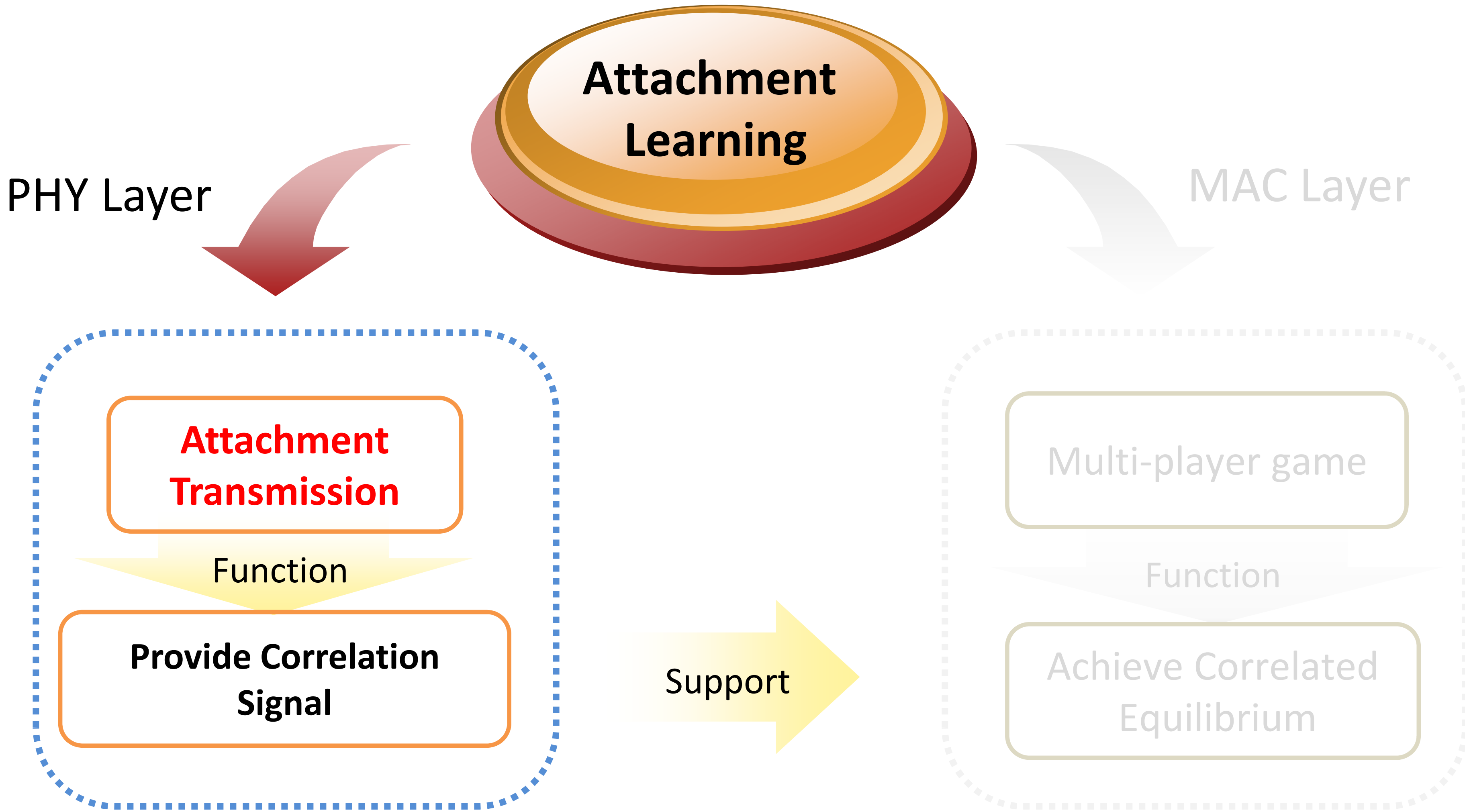
AT-Learning Illustration



Roadmap

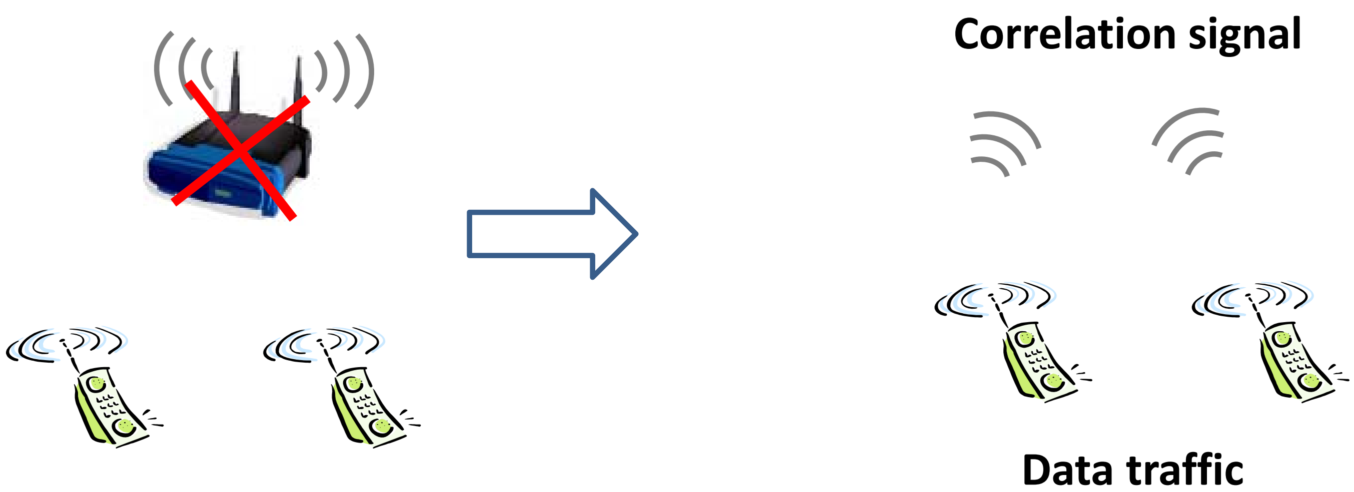
- ~~Introduction~~
- ~~Motivation~~
- **AT-Learning Design**
  - Correlation signal generation
  - Correlation signal generation
- Performance Evaluation
- Conclusion

AT-Learning Architecture



Learning and Adaptation

- *Attachment transmission* to generate implicit coordination signal.
- Transmitting coordination signal and data traffic *simultaneously.*



Learning and Adaptation

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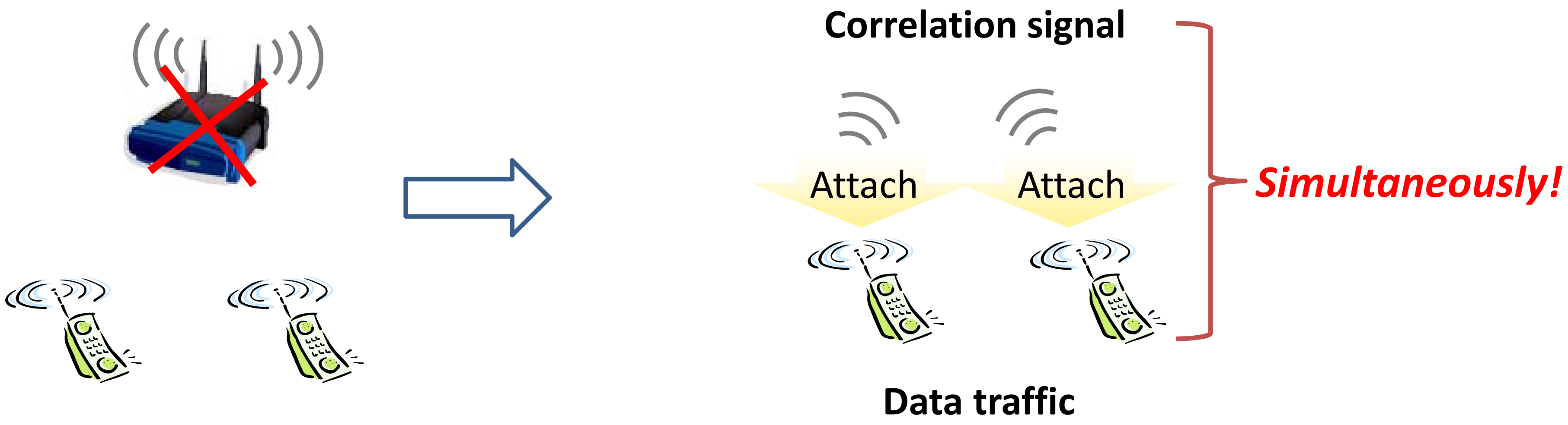
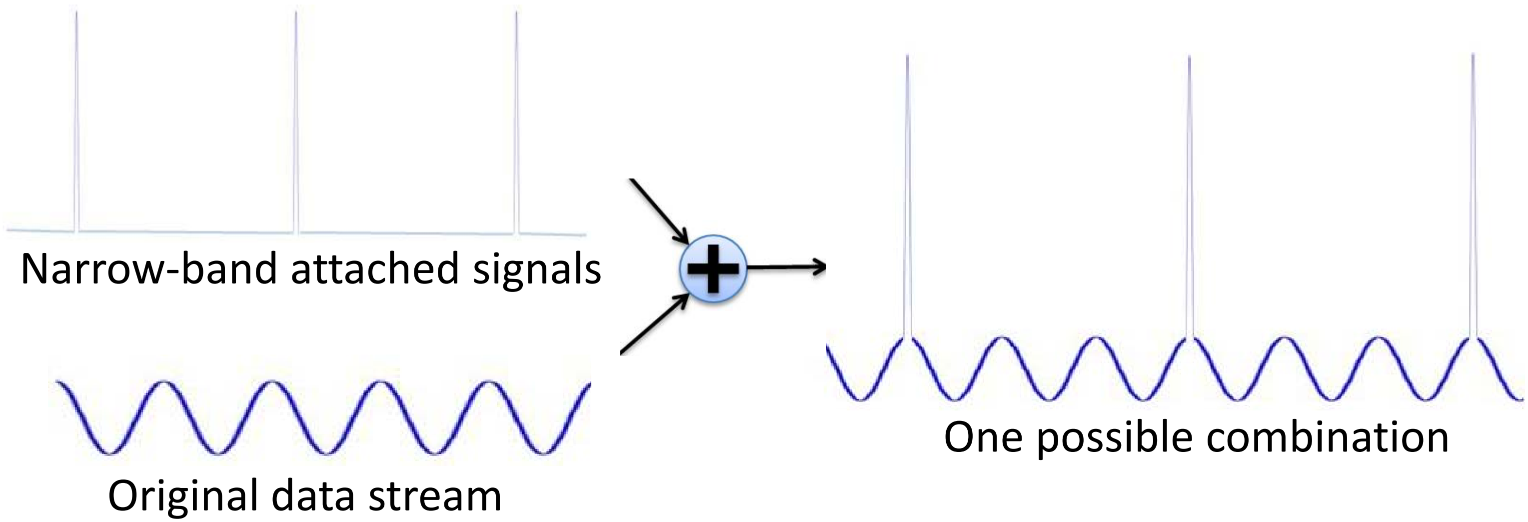


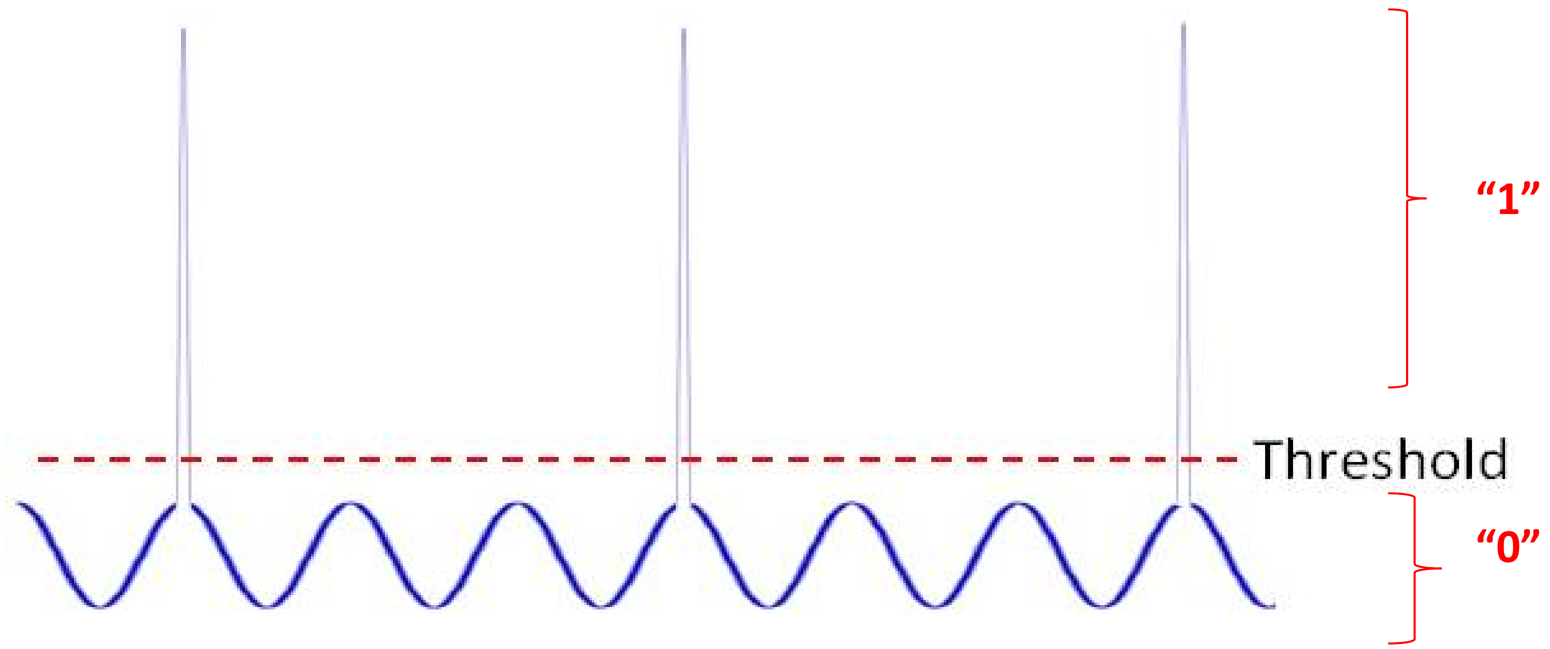
Attachment Transmission

- Narrower the channel width of ***attached signal.***
- Transmit the attached signal on ***one particular subcarrier*** with **higher energy.**



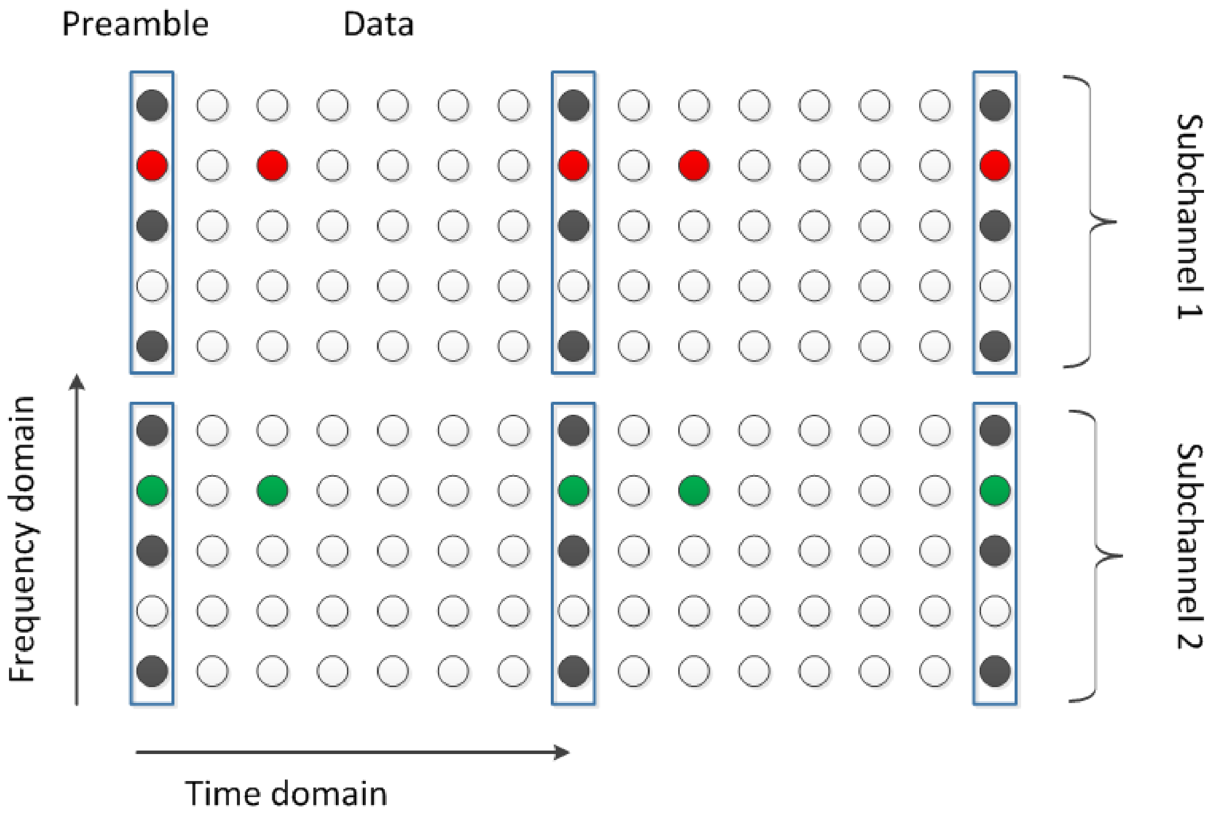
Attachment Detection

- ***Detect*** and ***record*** the energy which exceeds the threshold



Attachment Cancellation

- ***Record*** the attached signal on "clean" preamble
- ***Cancel out*** the attached signal in subsequent data



Attachment Cancellation

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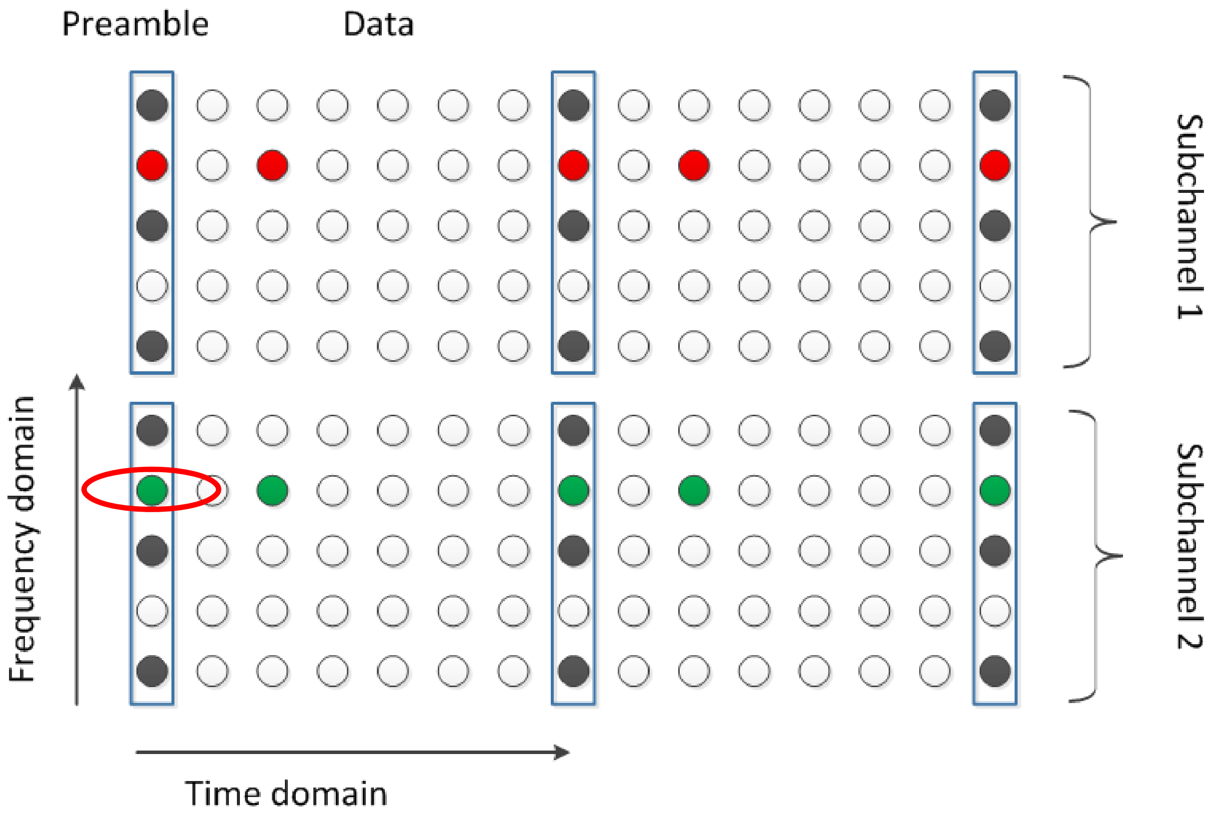

Attachment Cancellation

- ***Record*** the attached signal on "clean" preamble
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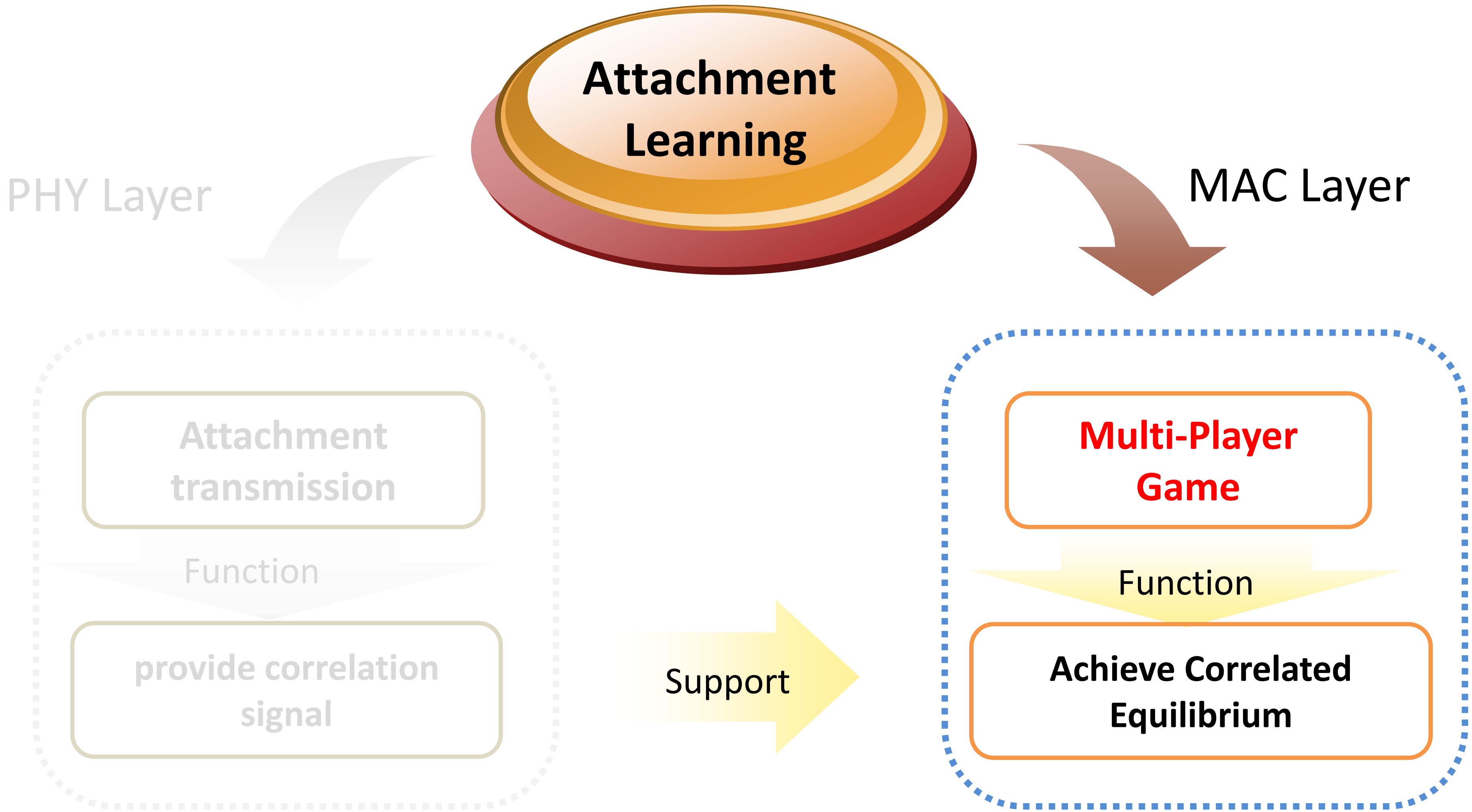
Roadmap

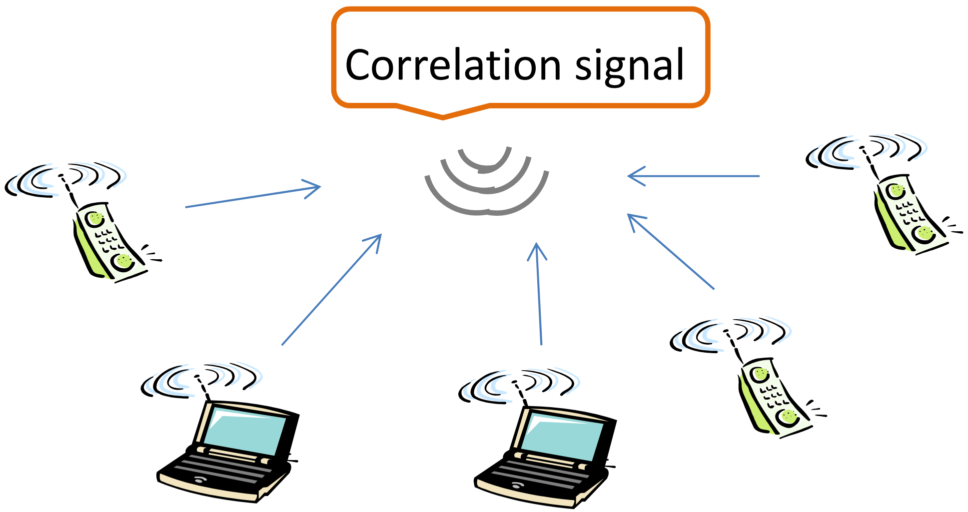
- ~~Introduction~~
- ~~Motivation~~
- **AT-Learning Design**
  - ~~Correlation signal generation~~
  - Correlation signal learning
- Performance Evaluation
- Conclusion

AT-Learning Architecture



MAC Layer design

- To achieve the *Correlated Equilibrium* of Multiplayer game, we propose a ***Learning Based MAC***



To ***learn*** the access decision according to each value of the *correlation signal*

Learning Based MAC

- Each Station has a ***strategy table*** to store *channel access decisions* for different *coordination signals*.

Strategy table for node m

C_t	0	1	2	…	C-2	C-1
$f_m(C_t)$	S_1	0	S_5	…	S_2	S_6

Learning Based MAC

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Strategy table for node m

Correlation signal

C_t	0	1	2	…	C-2	C-1
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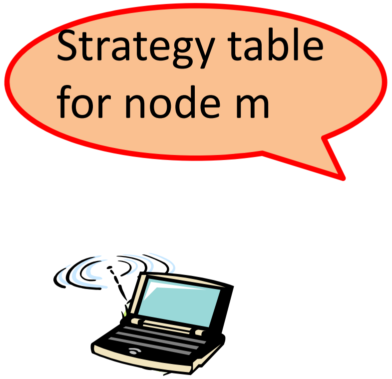

Correlation signal

C_t	0	1	2	…	C-2	C-1
$f_m(C_t)$	S_1	0	S_5	…	S_2	S_6

Channel for transmission

Learning Based MAC

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Strategy table for node m

Correlation signal

C_t	0	1	2	…	C-2	C-1
$f_m(C_t)$	S_1	0	S_5	…	S_2	S_6

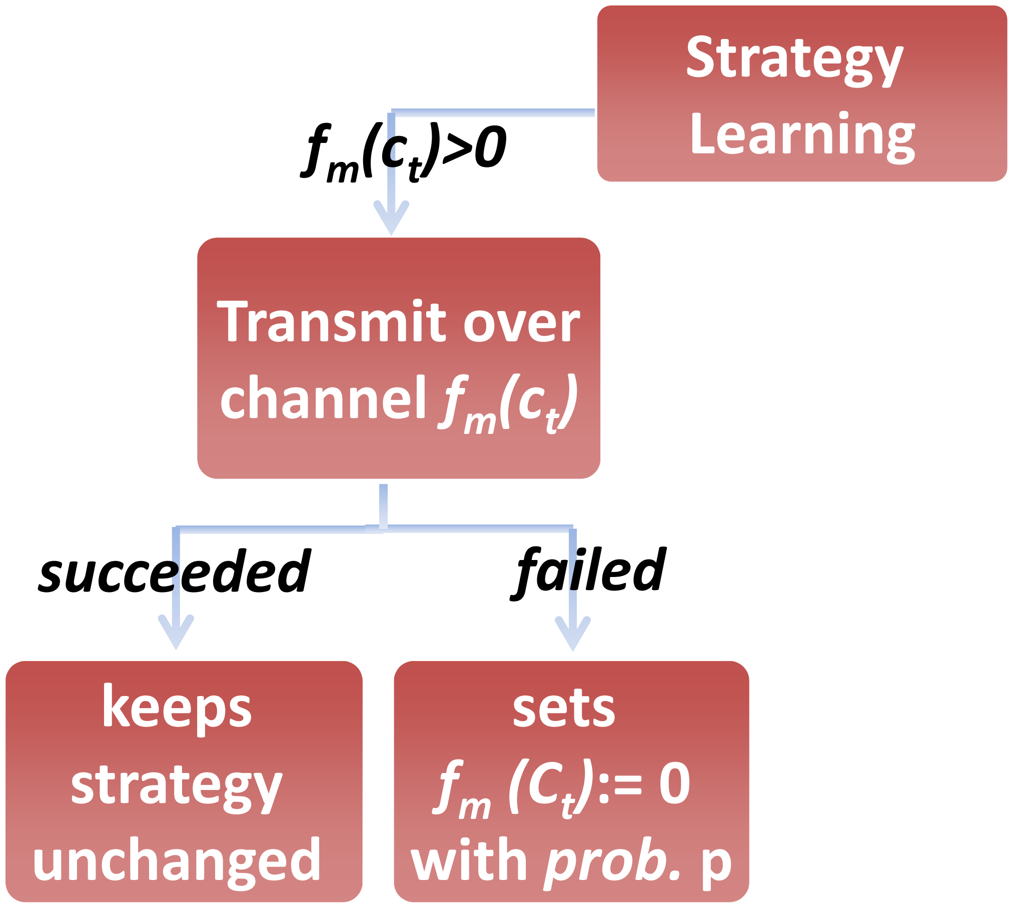
Channel for transmission

$f_m(c)$ is initialized uniformly at random

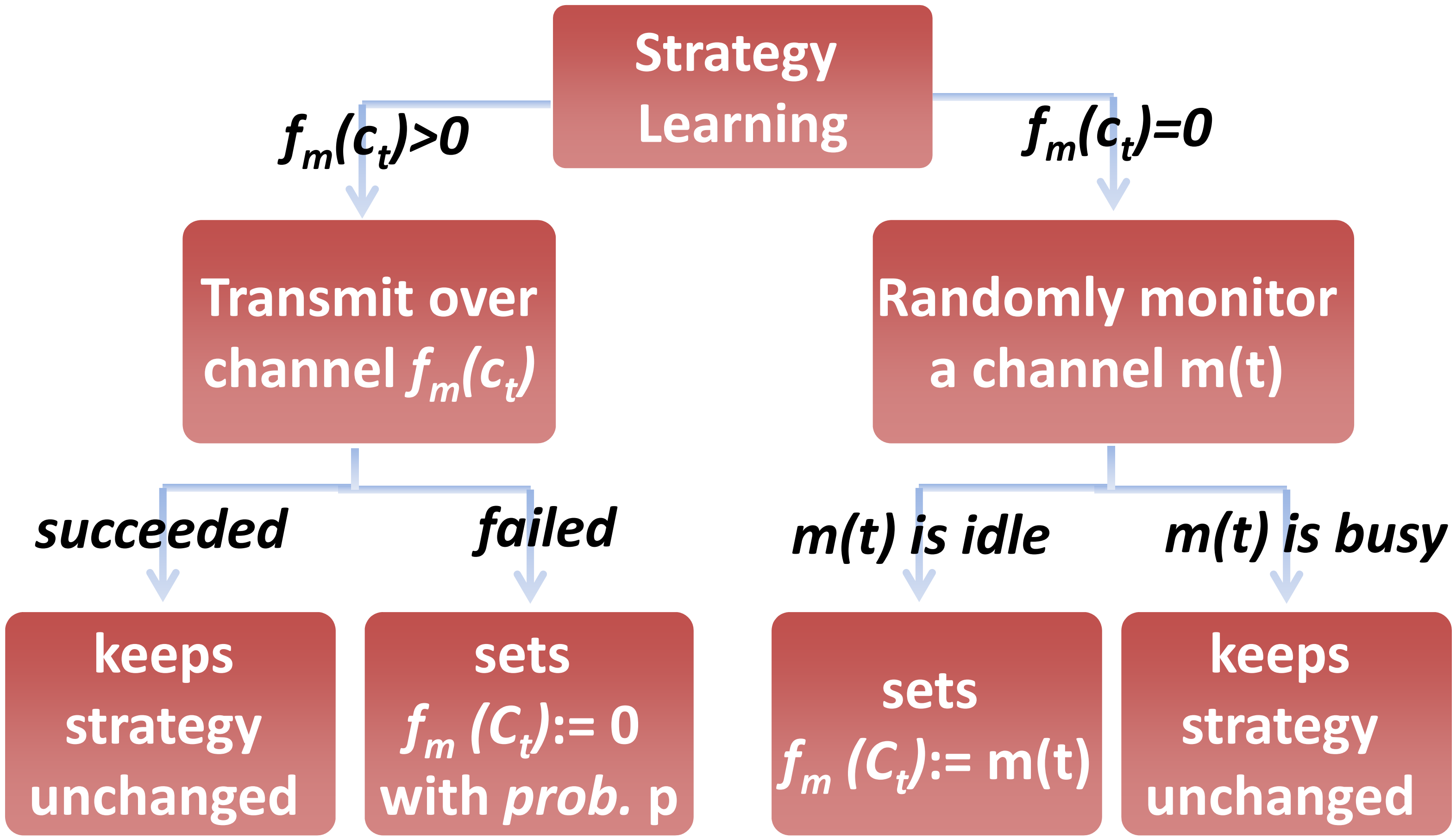
Learning and Adaptation

Strategy Learning

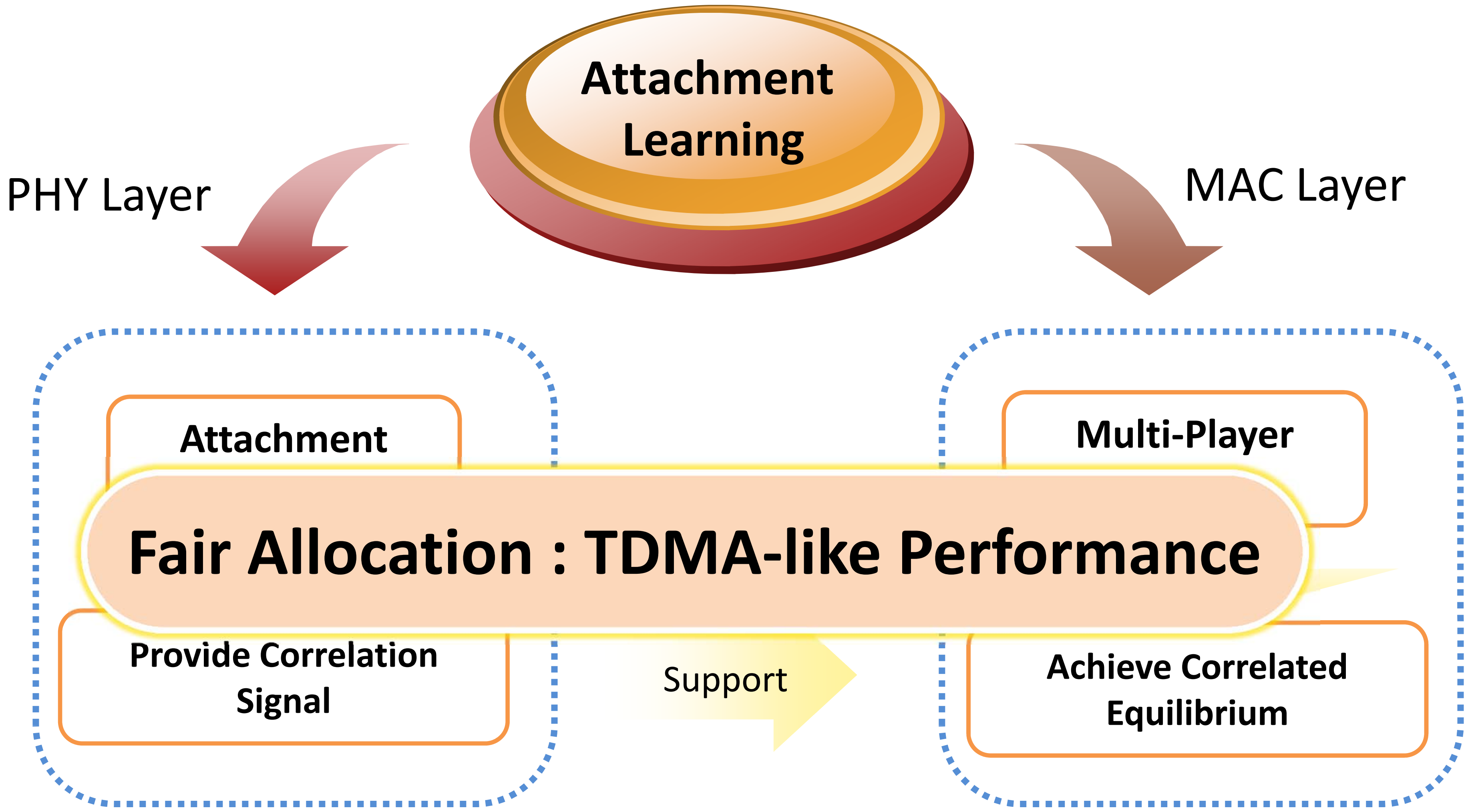
Learning and Adaptation



Learning and Adaptation



AT-Learning Review

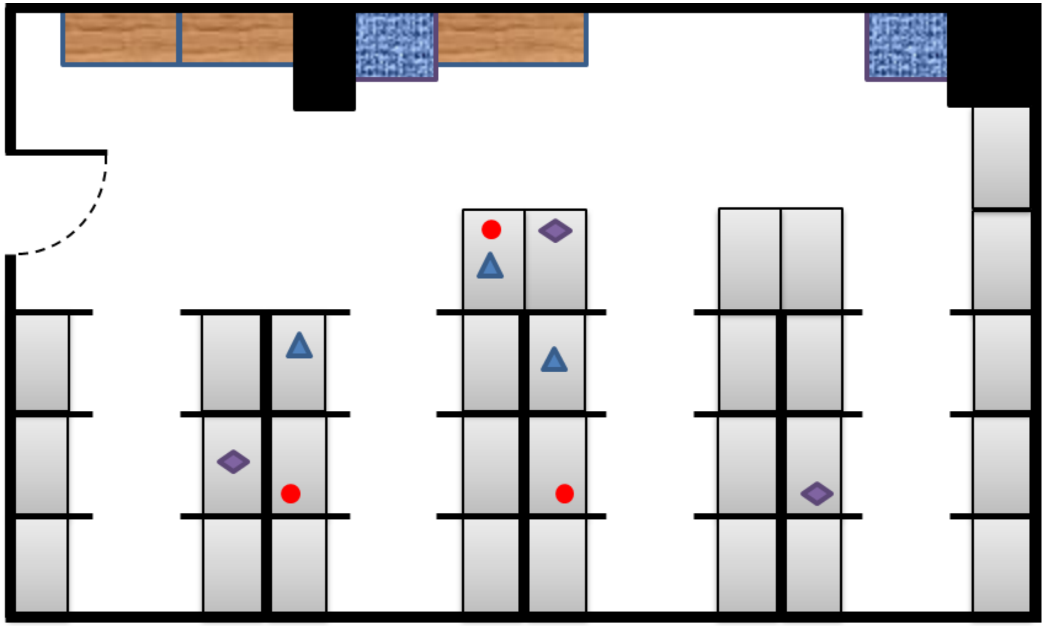


Roadmap

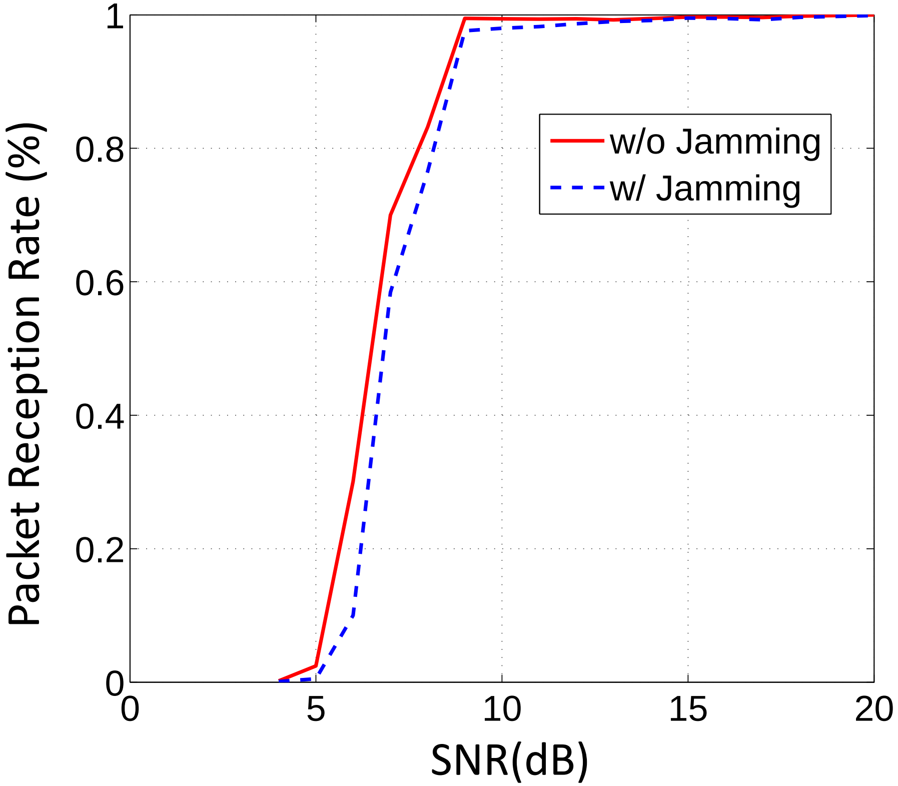
- ~~Introduction~~
- ~~Motivation~~
- ~~AT-Learning Design~~
- Performance Evaluation
  - Feasibility of Attachment Transmission
  - Performance of Correlation Learning
  - Performance of AT-Learning
- Conclusion

Implementation

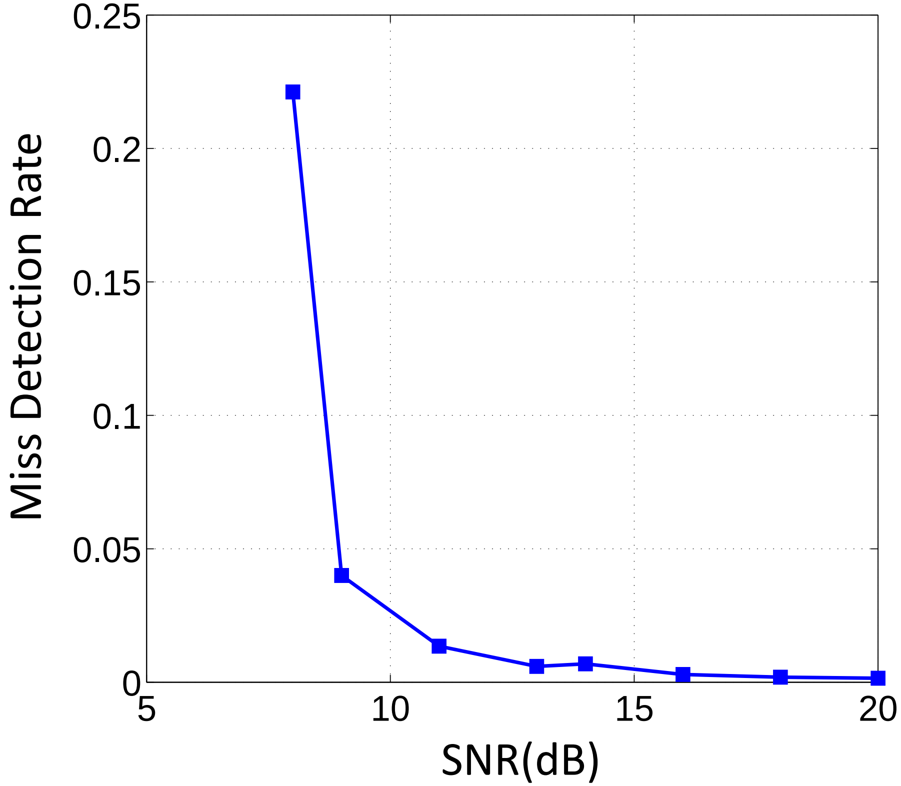
- GNU radio with 10 USRP2 nodes



Attachment Transmission



Feasibility

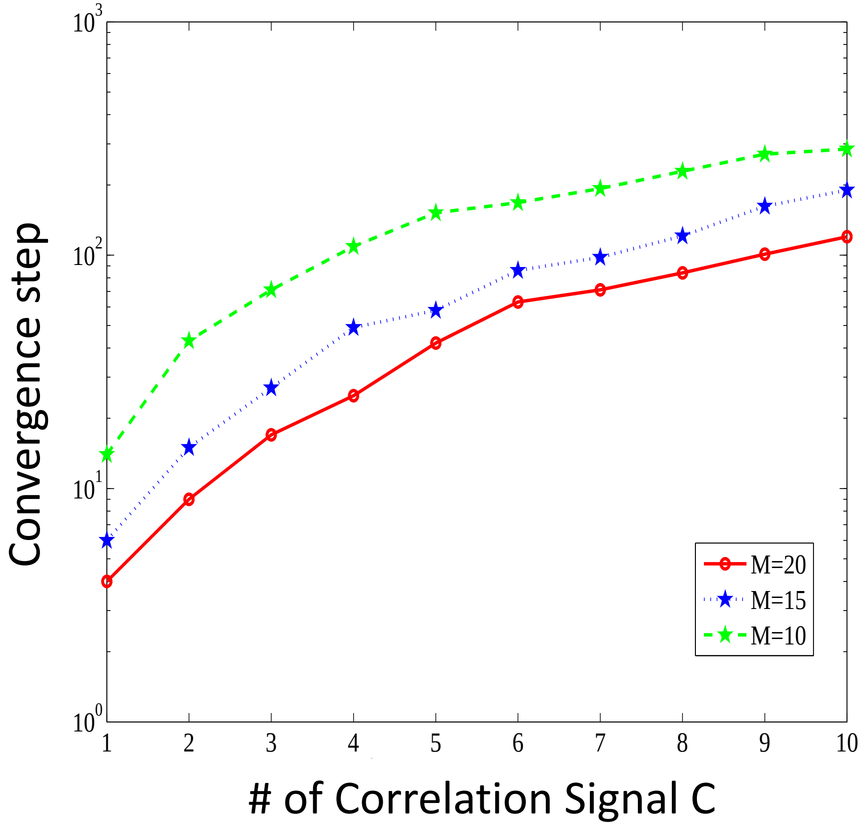


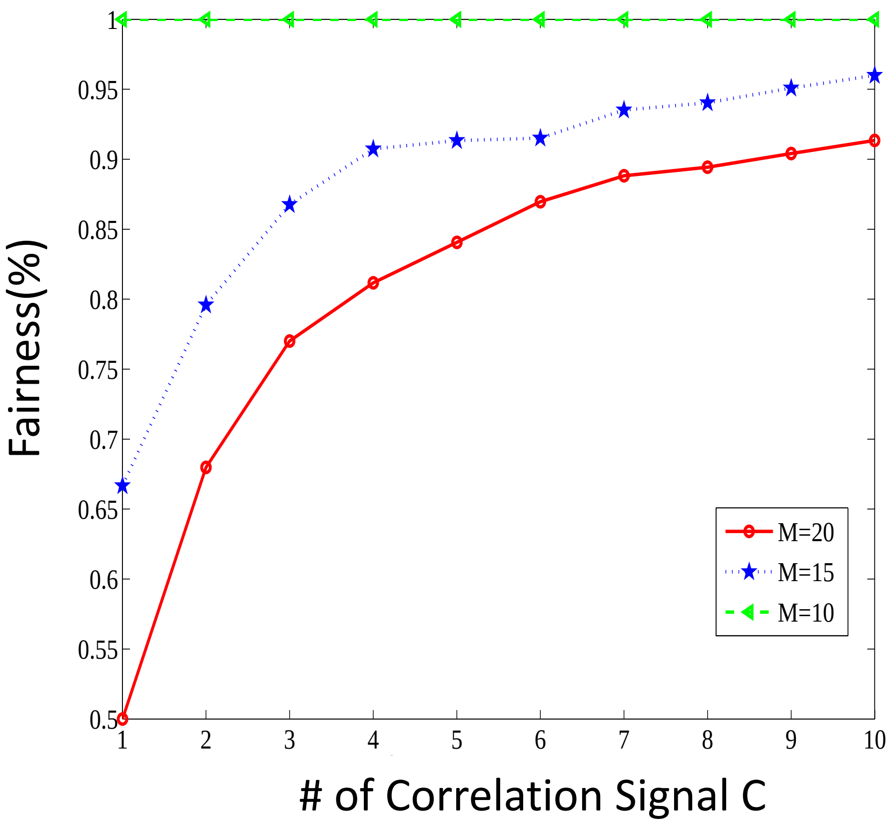
Reliability

Roadmap

- ~~Introduction~~
- ~~Motivation~~
- ~~AT-Learning Design~~
- Performance Evaluation
  - ~~Feasibility of Attachment Transmission~~
  - Performance of Correlation Learning
  - Performance of AT-Learning
- Conclusion

Correlation Learning





C cannot be too large

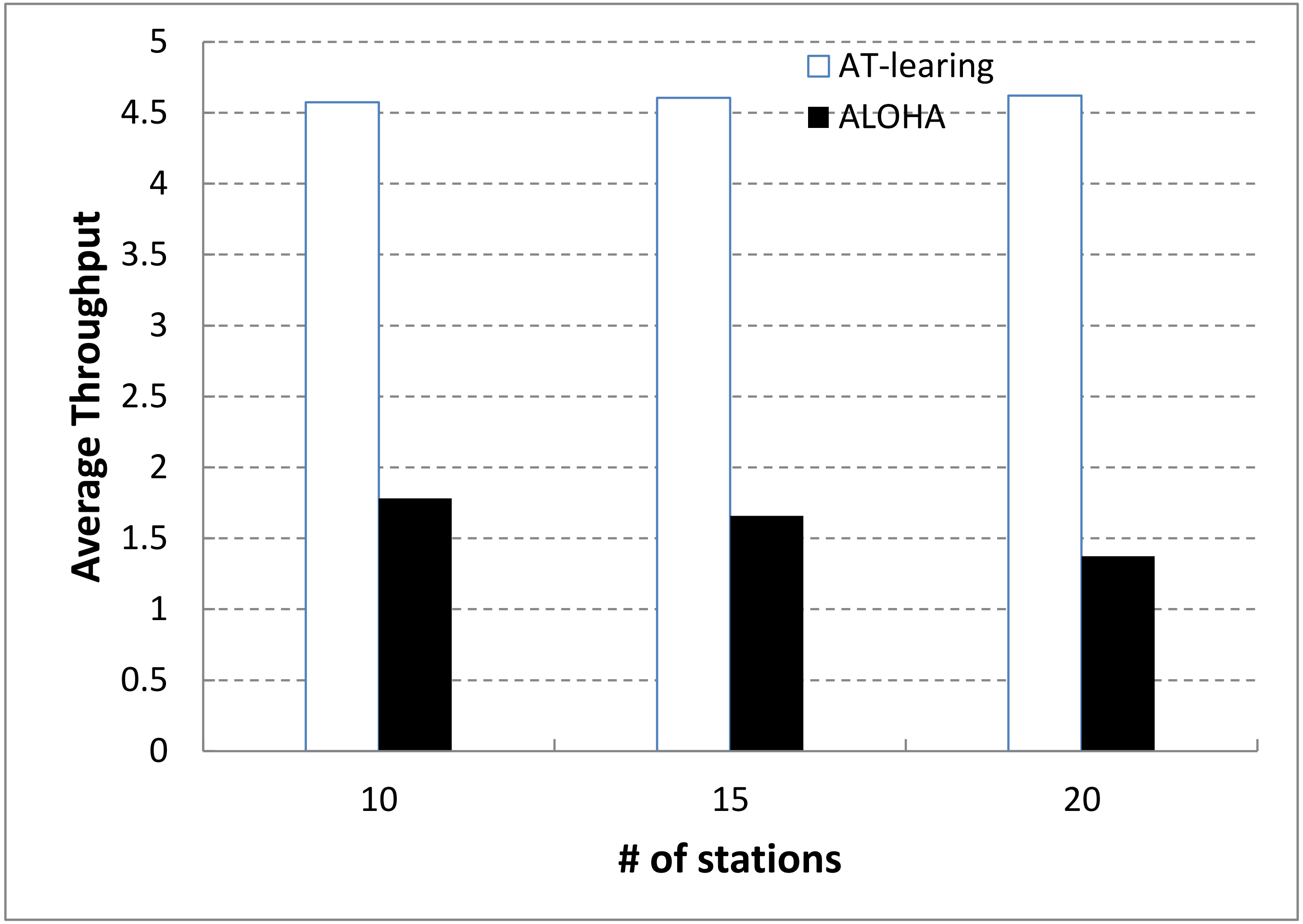
C cannot be too small

Tradeoff

Roadmap

- ~~Introduction~~
- ~~Motivation~~
- ~~AT-Learning Design~~
- Performance Evaluation
  - ~~Feasibility of Attachment Transmission~~
  - ~~Performance of Correlation Learning~~
  - Performance of AT-Learning
- Conclusion

AT-Learning



Gain: up to 300%

Roadmap

- Introduction
- Motivation
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- Performance Evaluation
- **Conclusion**

Conclusion

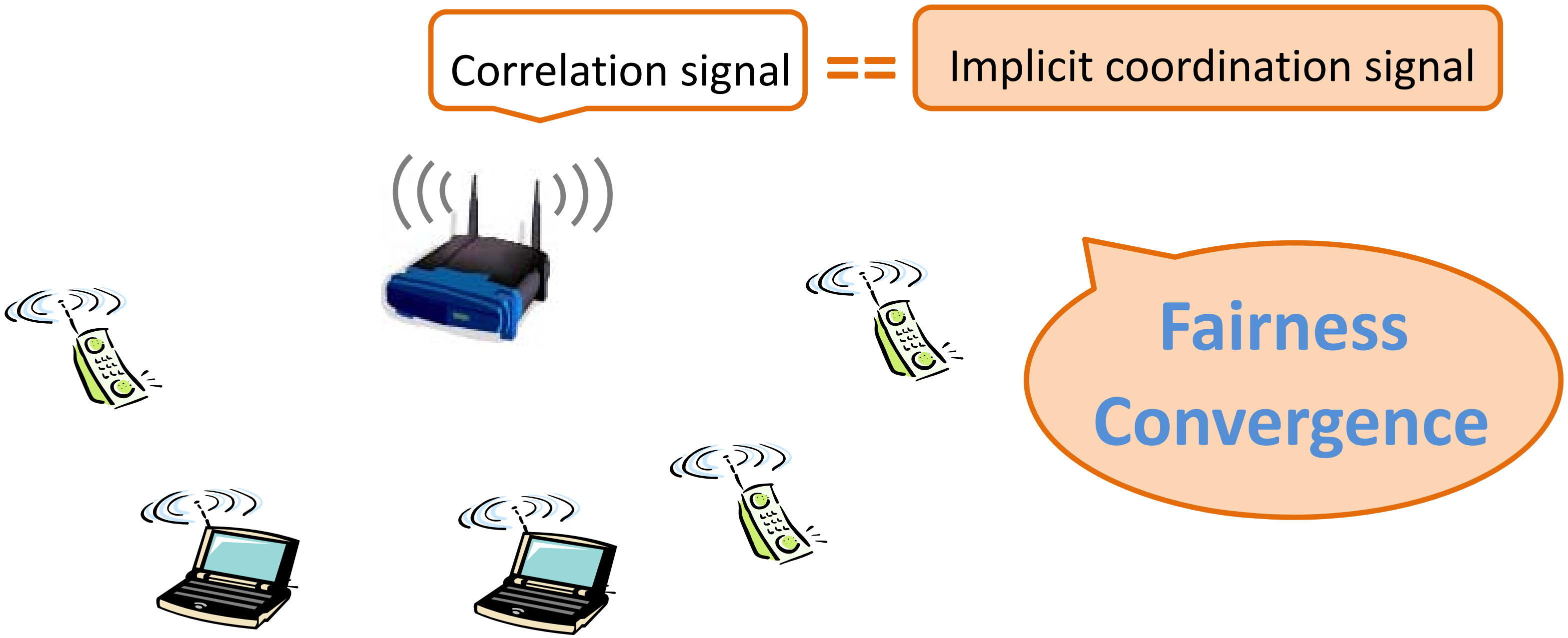
- We design a cross layer *Attachment-Learning* for multichannel allocation in *distributed wireless networks*.
- We design *Attachment Transmission* to *cost-effectively* transmit correlation signal.
- We formulize the multichannel allocation problem as multi-player game to achieve *Correlative Equilibrium*, which is *TDMA-like performance*.

Thank You !

Q&A

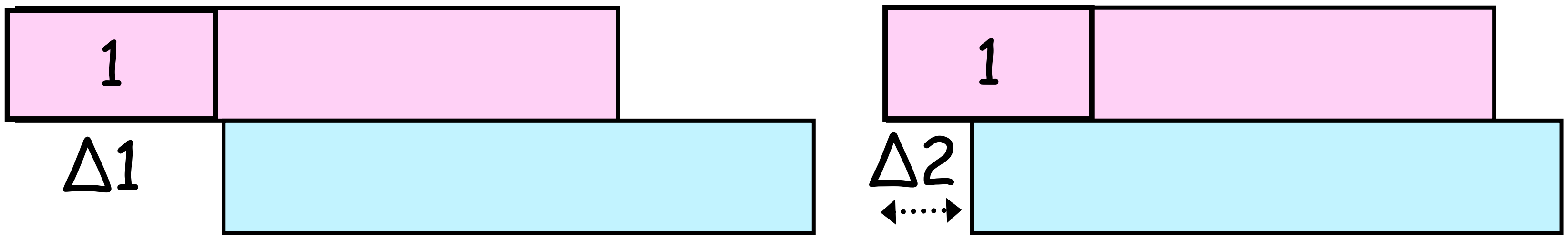
Backup

- *How to ensure fairness and convergence time*



Backup

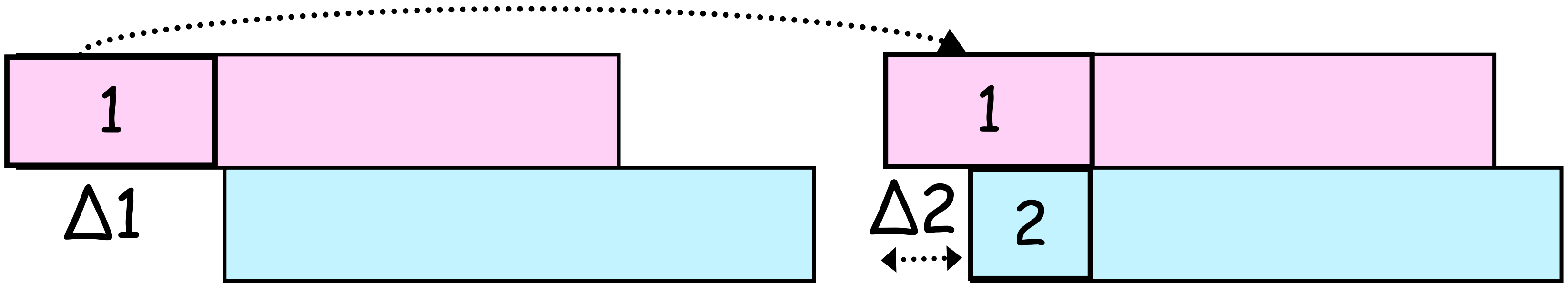
- ZigZag



$$\Delta 1 \neq \Delta 2$$

Backup

- ZigZag



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Backup

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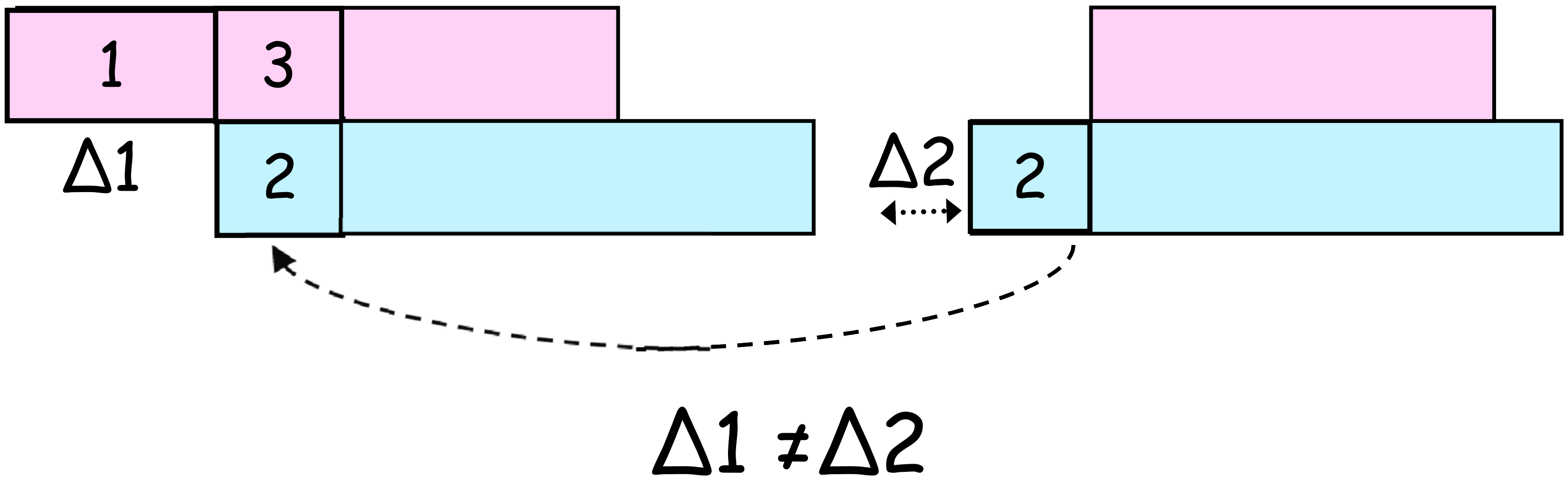

Backup

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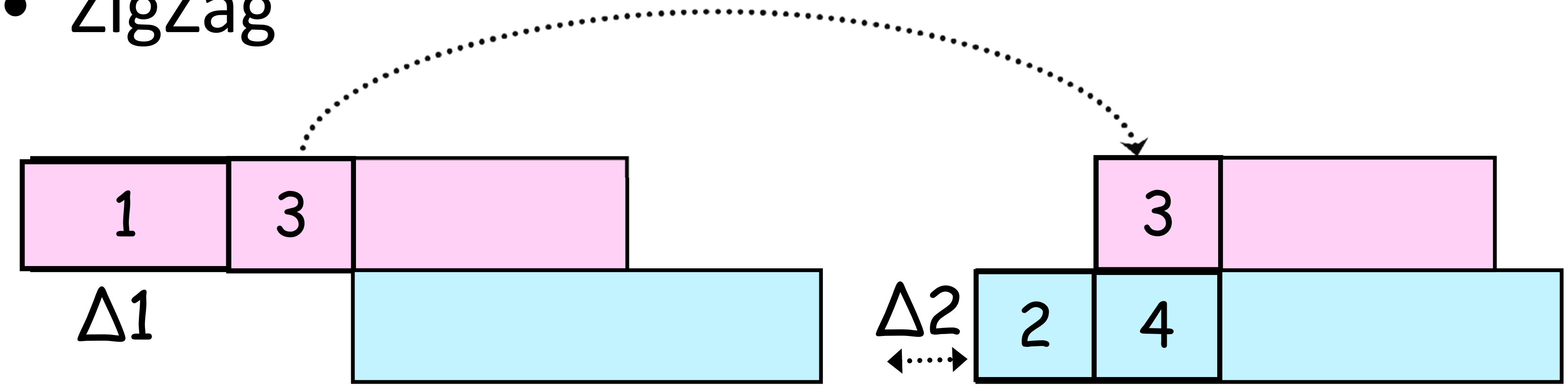

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Backup

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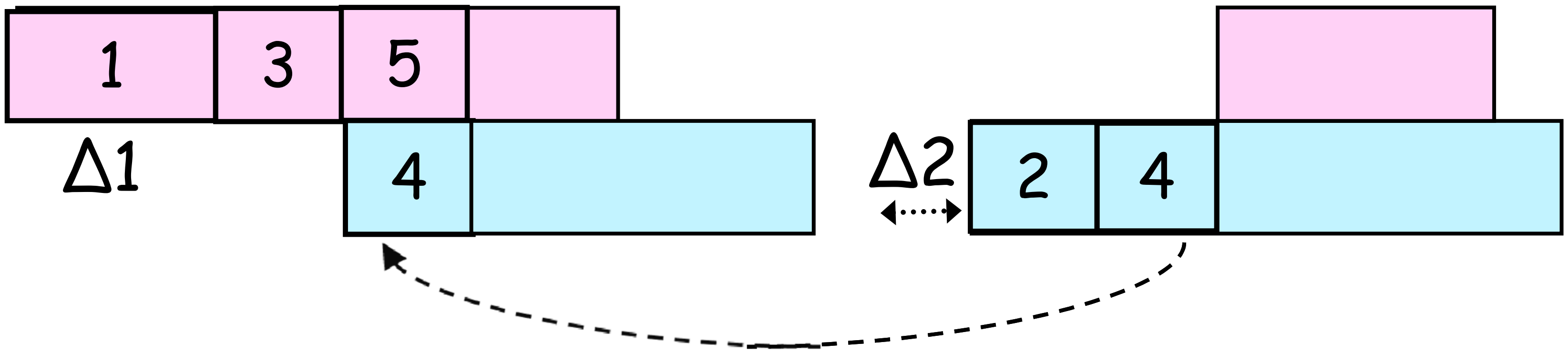

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Backup

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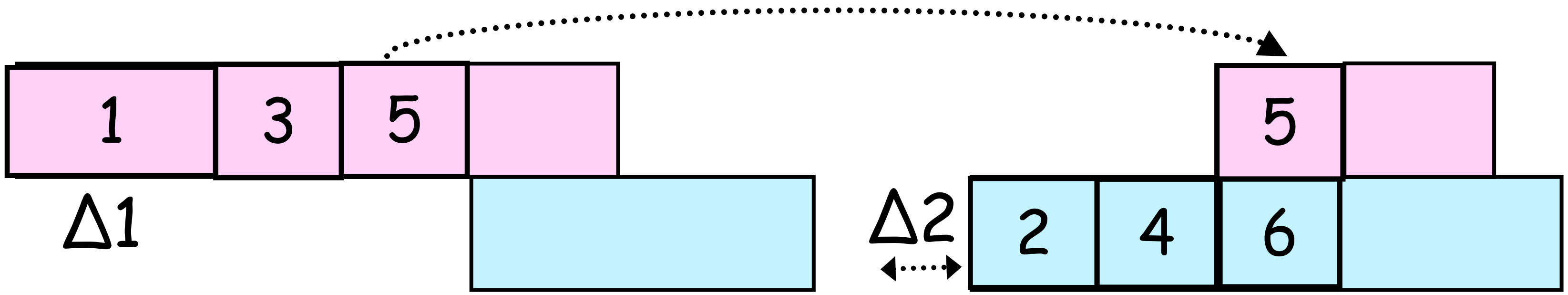
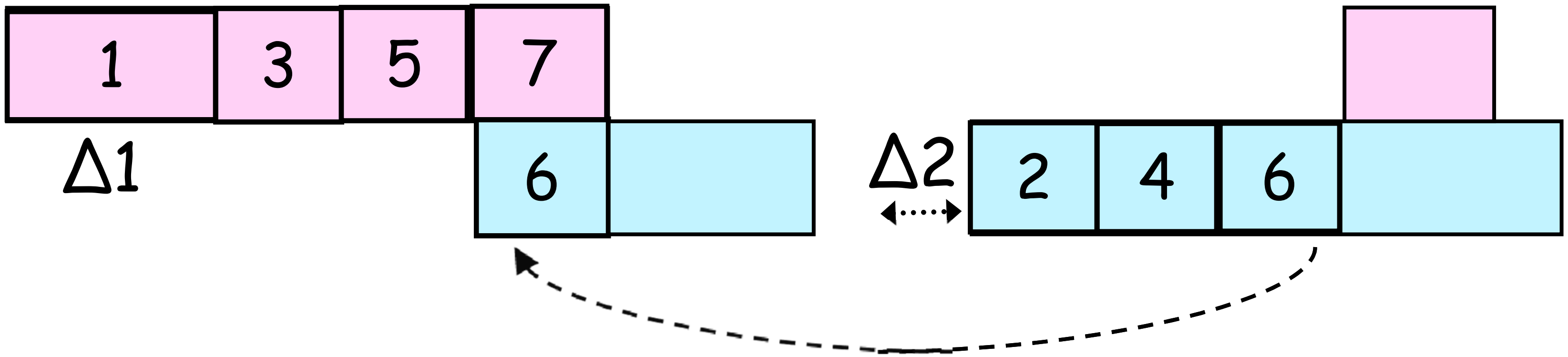


$$\Delta 1 \neq \Delta 2$$

Backup

- ZigZag



$\Delta 1 \neq \Delta 2$

Backup

- Channel

  Subchannel space: C: = {0, 1… C-1}
- Implicit coordination signal

  Signal space: K :={ 0, 1… K-1}
- Station

  Station space: N (Normally N>C)

  Every station observe the same coordination signal