Potential Pitfalls of the Message in Message Mechanism in Modern 802.11 Networks

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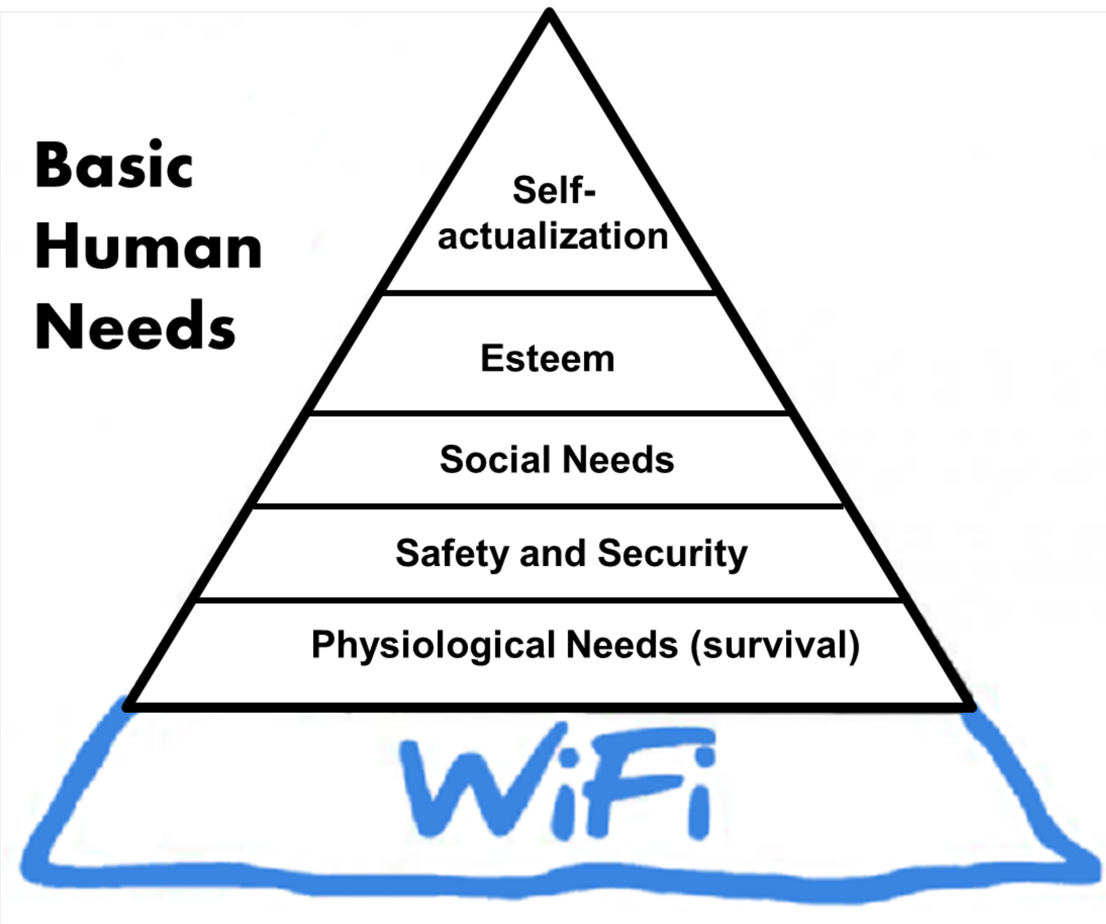
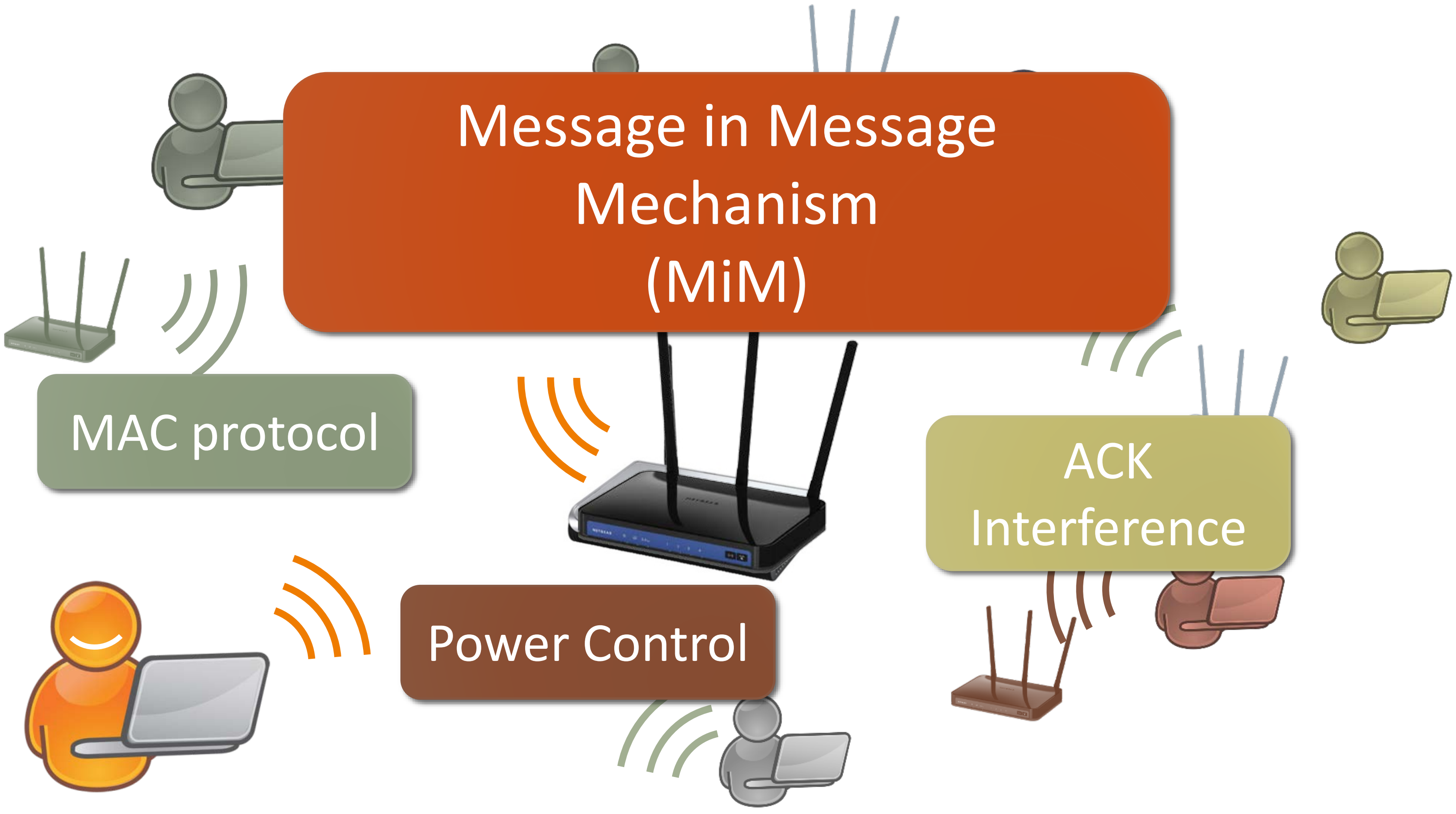
Wi-Fi is Ubiquitous



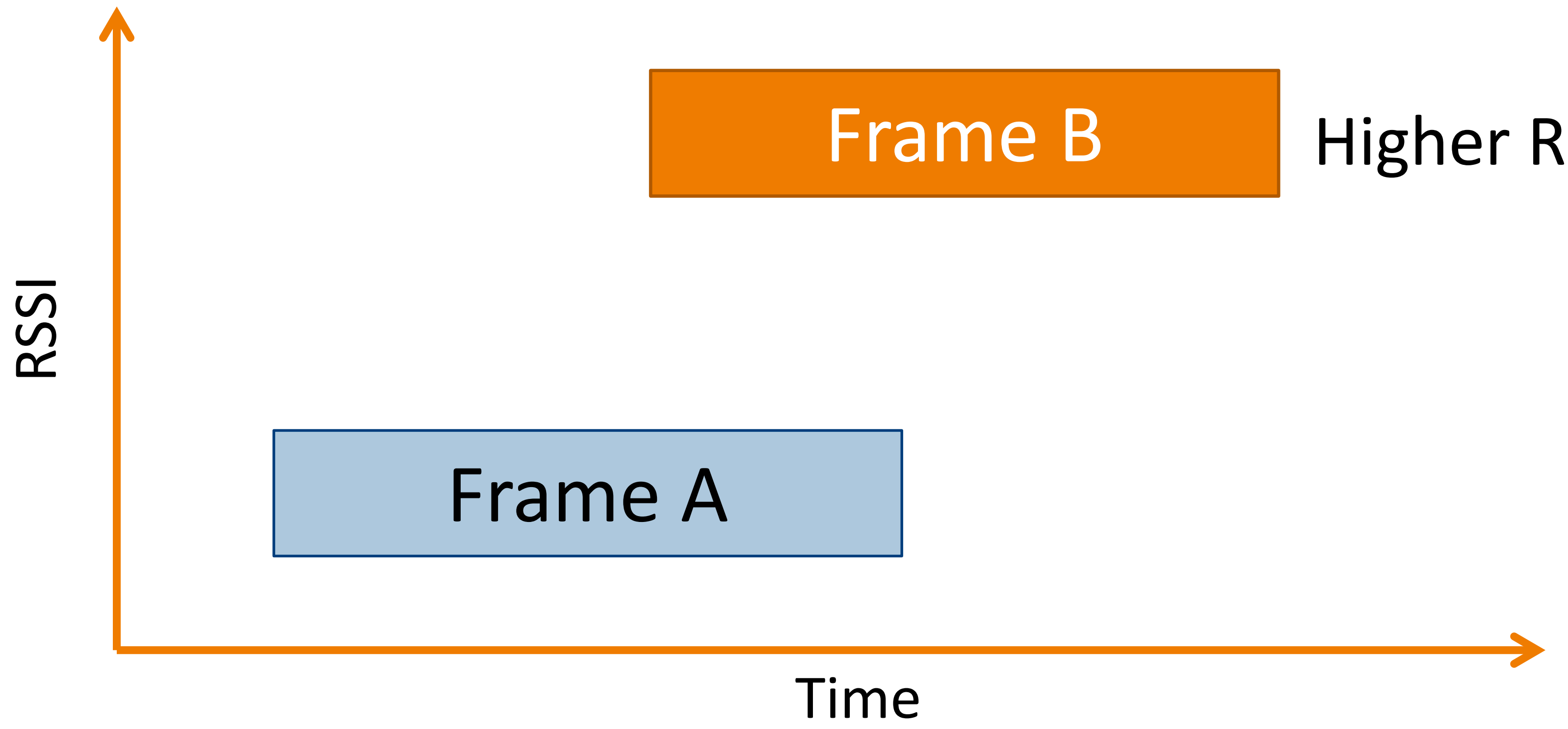
The Problem


Message in Message Mechanism (MiM)
MAC protocol
ACK Interference
Power Control

What is MiM?

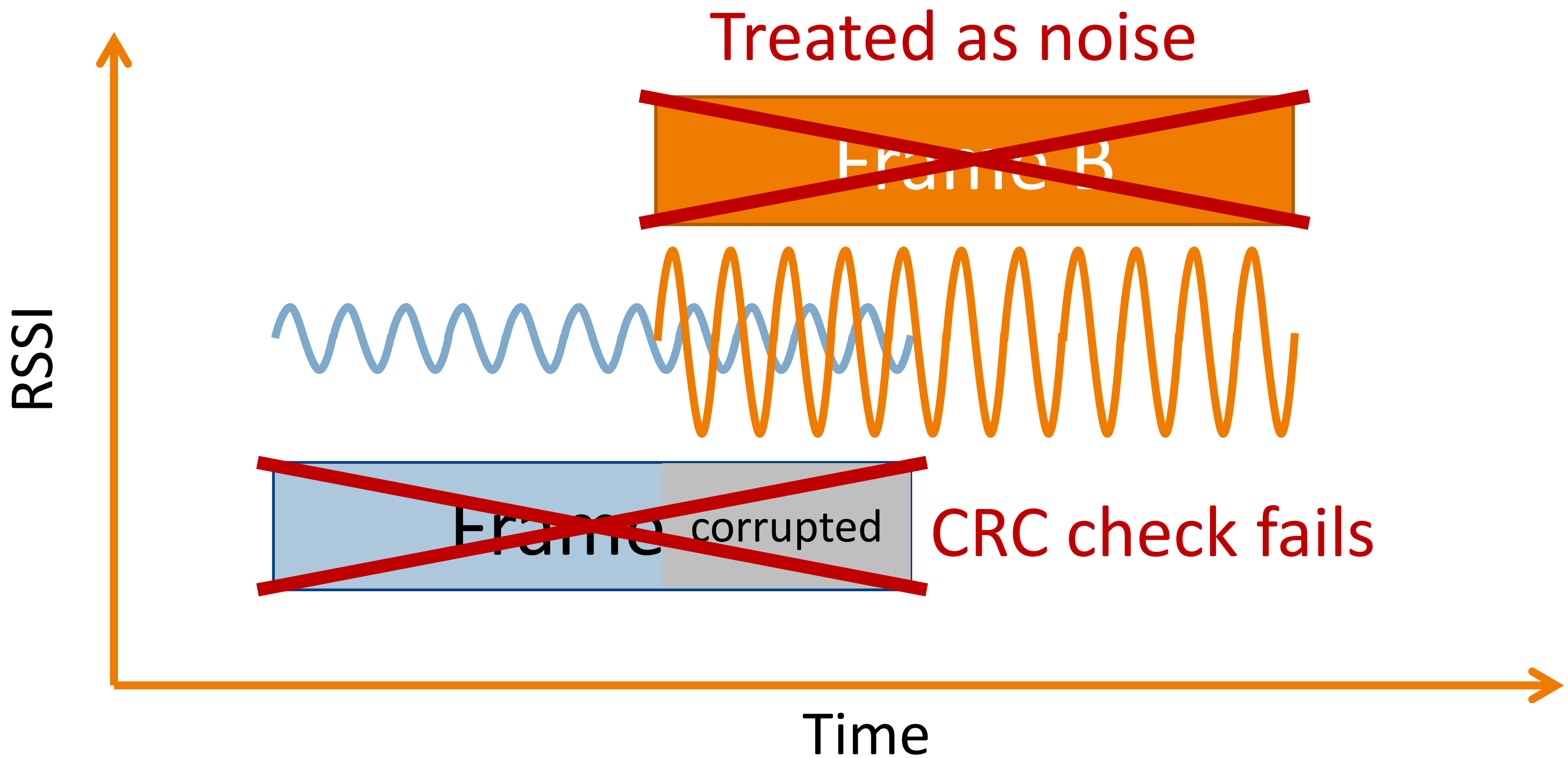
MESSAGE IN MESSAGE MECHANISM

Conventional Receiver w/o MiM



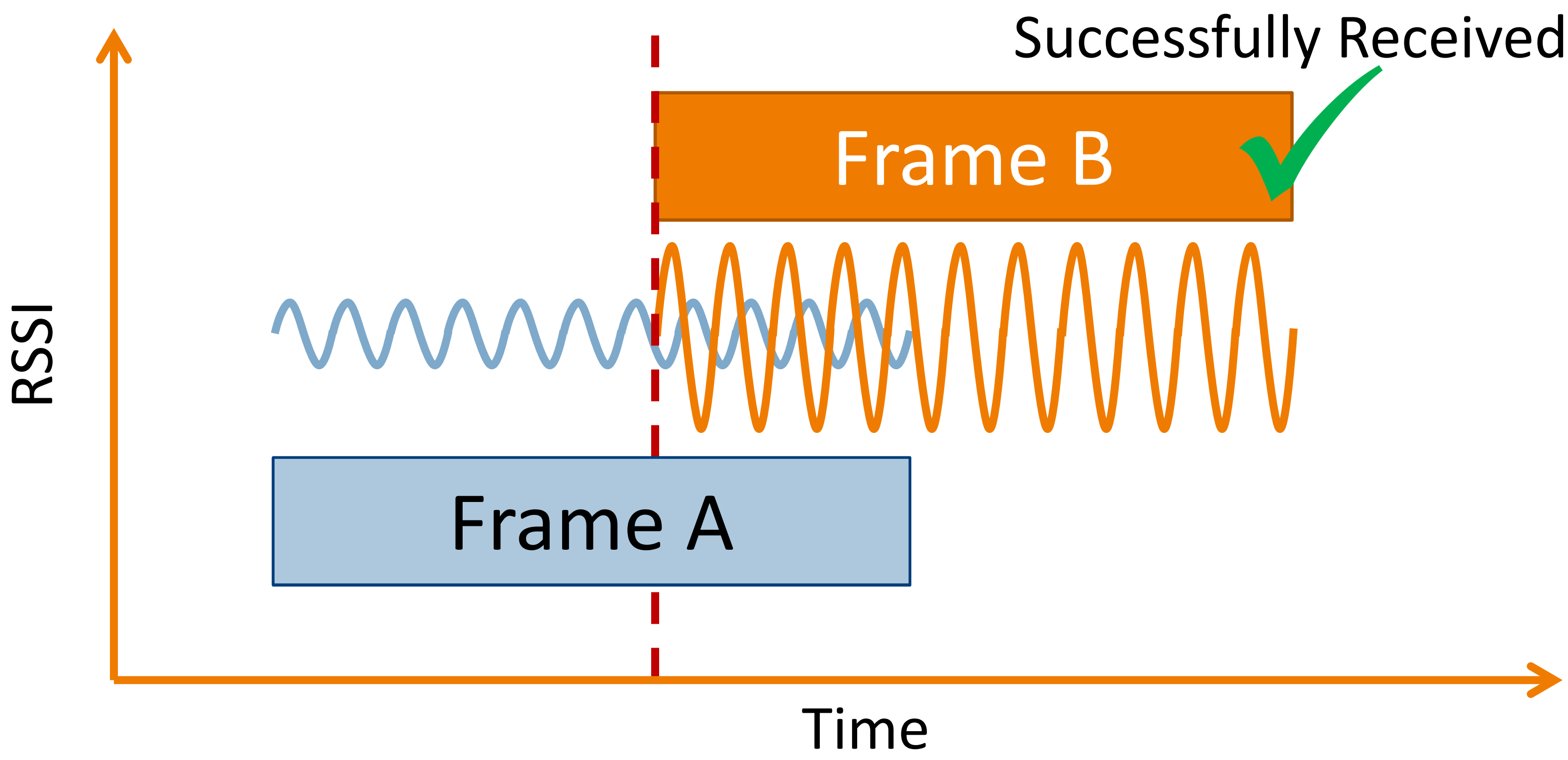
Reception of Conventional Receiver

Both frames are lost



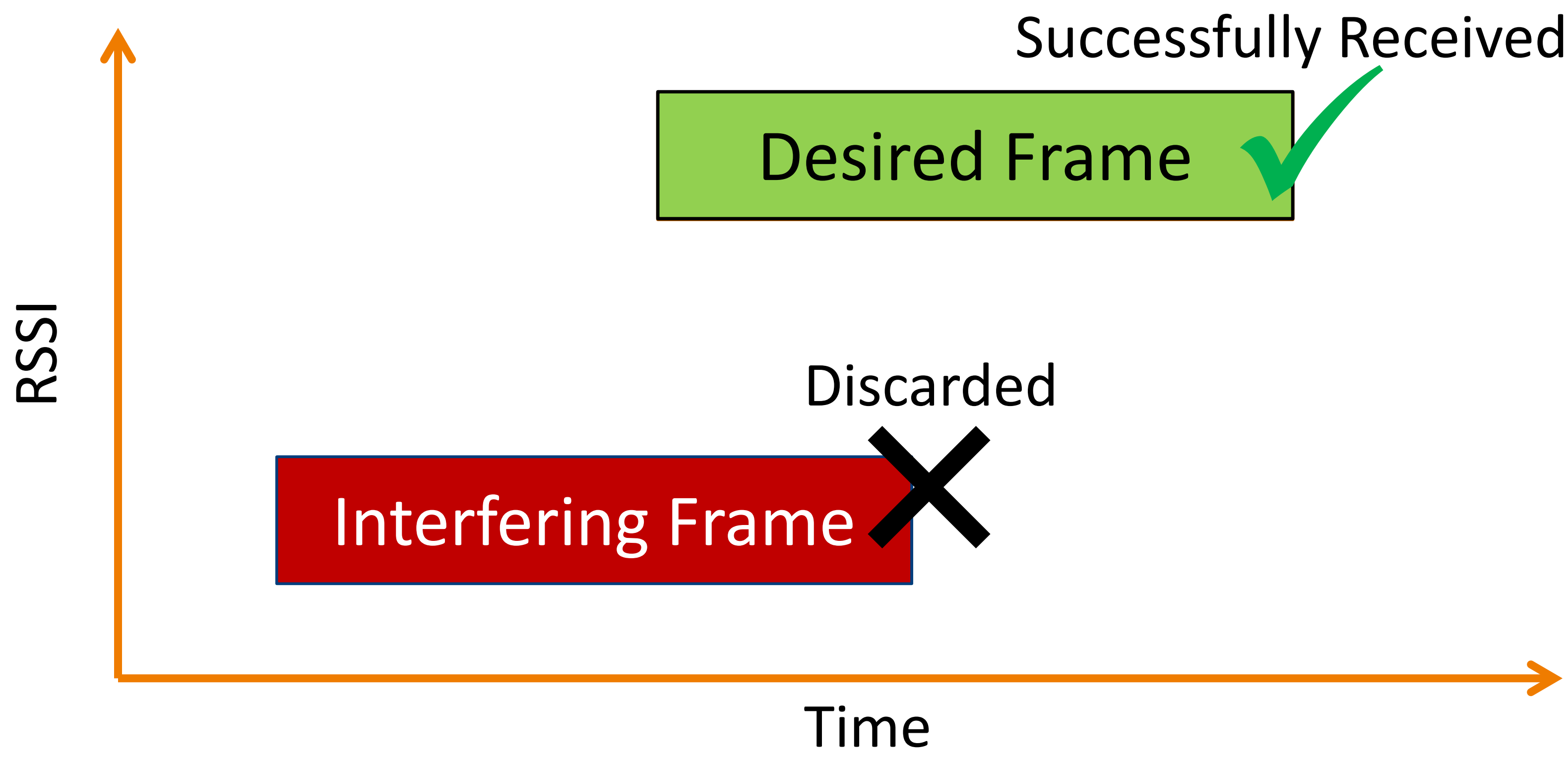
Message in Message (MiM)

Higher signal dominates weaker signal



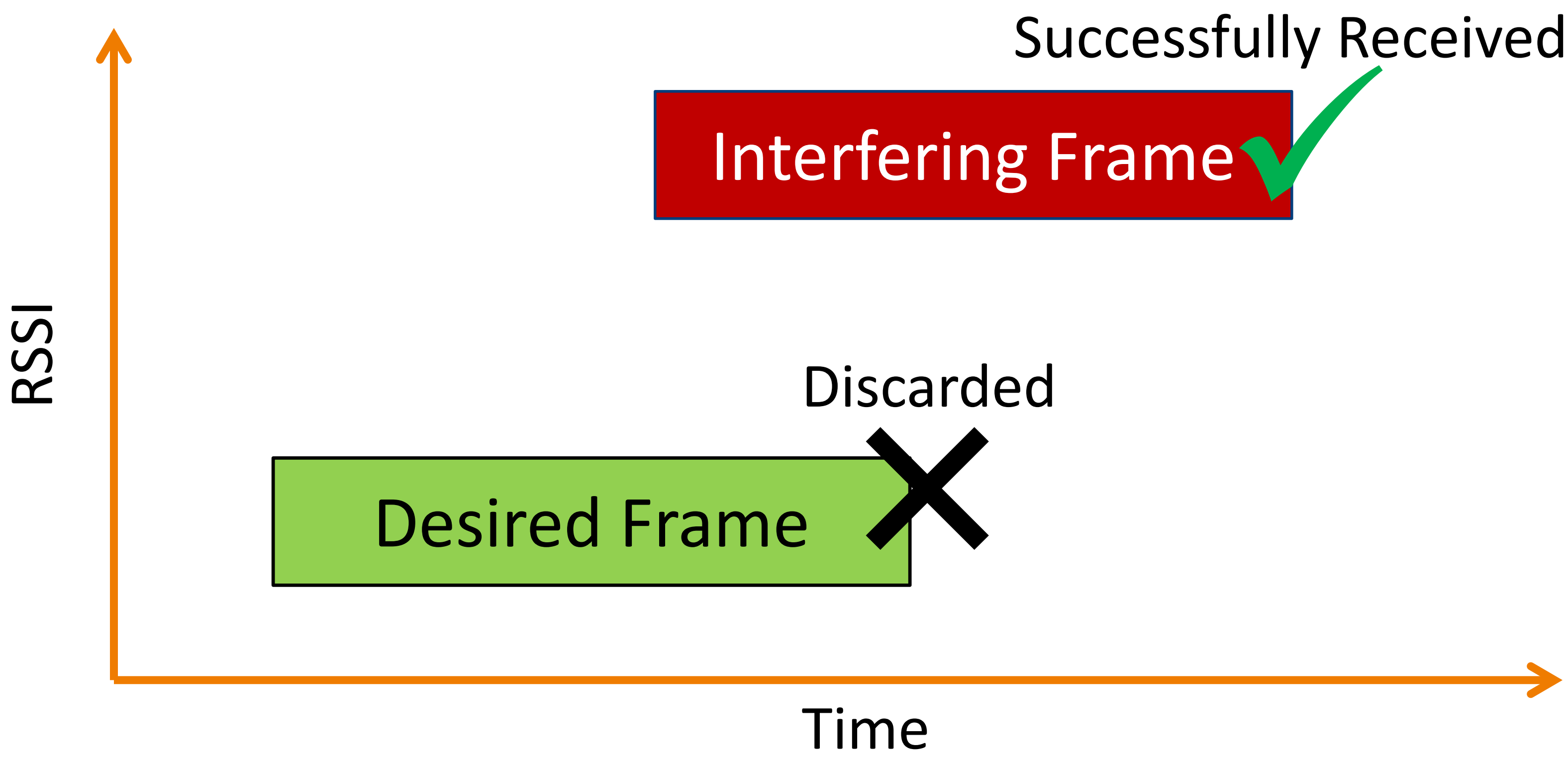
MiM is helpful

1. Salvaged otherwise lost frame



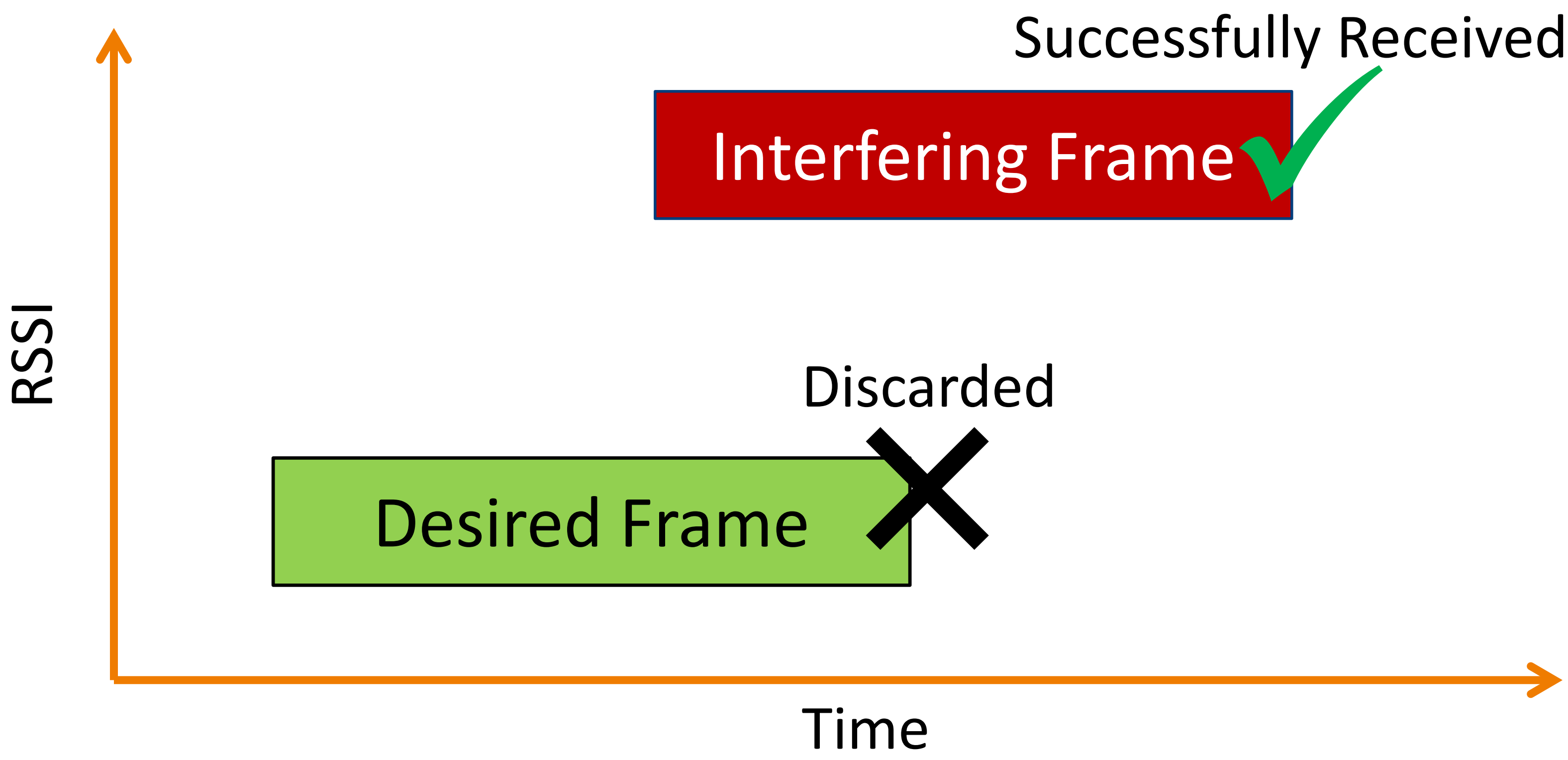
MiM is helpful

1. Salvaged otherwise lost frame
2. Desired frame is lost



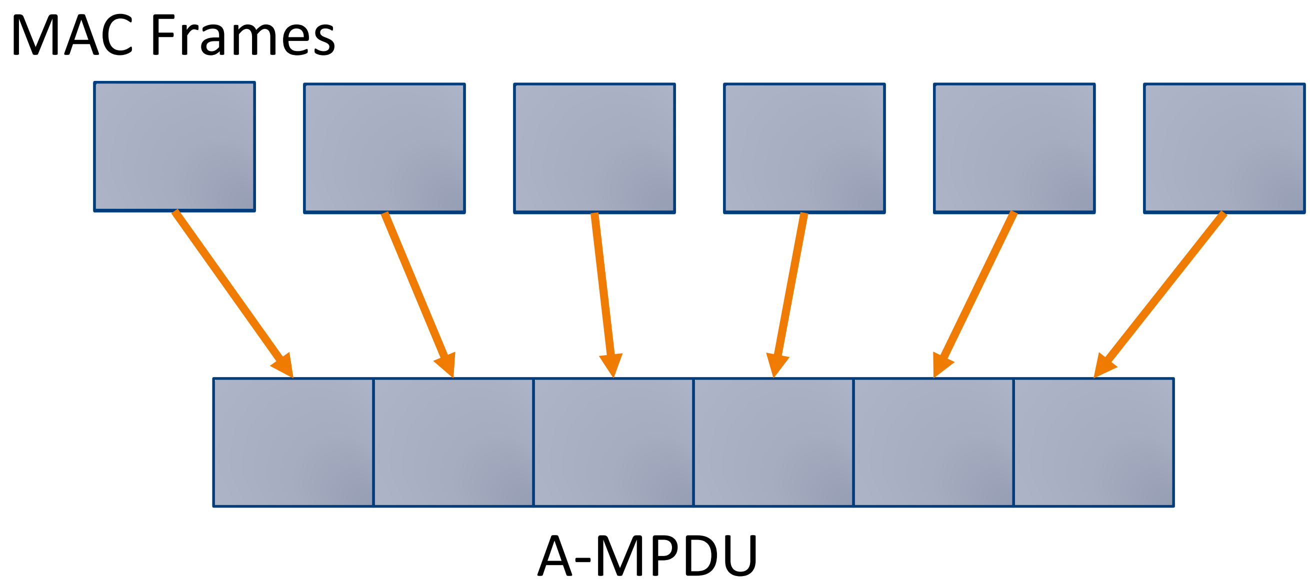
MiM is helpful, at least no harm

1. Salvaged otherwise lost frame
2. Desired frame is lost

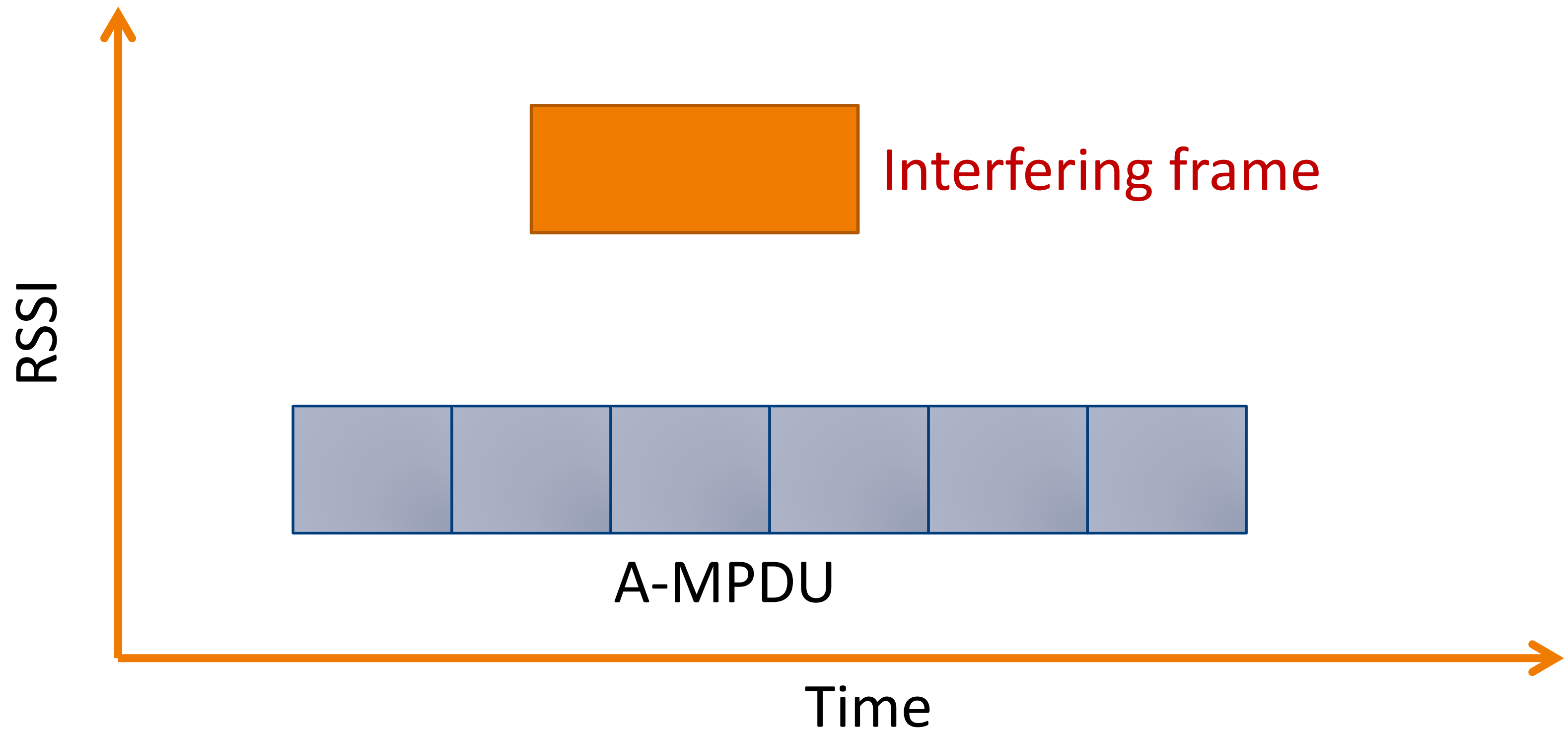


However…

Consider Aggregate MPDUs

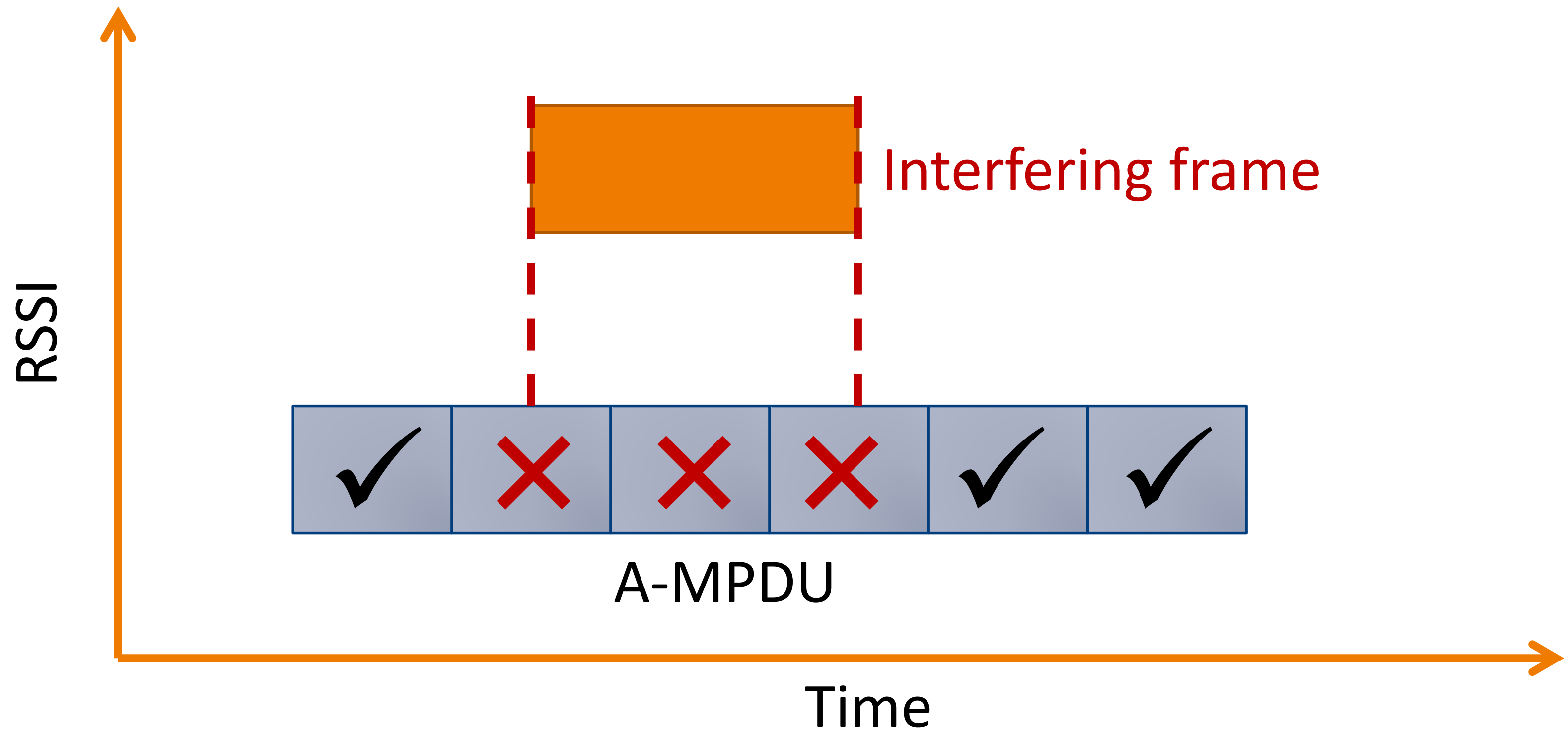


However... Consider A-MPDU



However… Consider A-MPDU

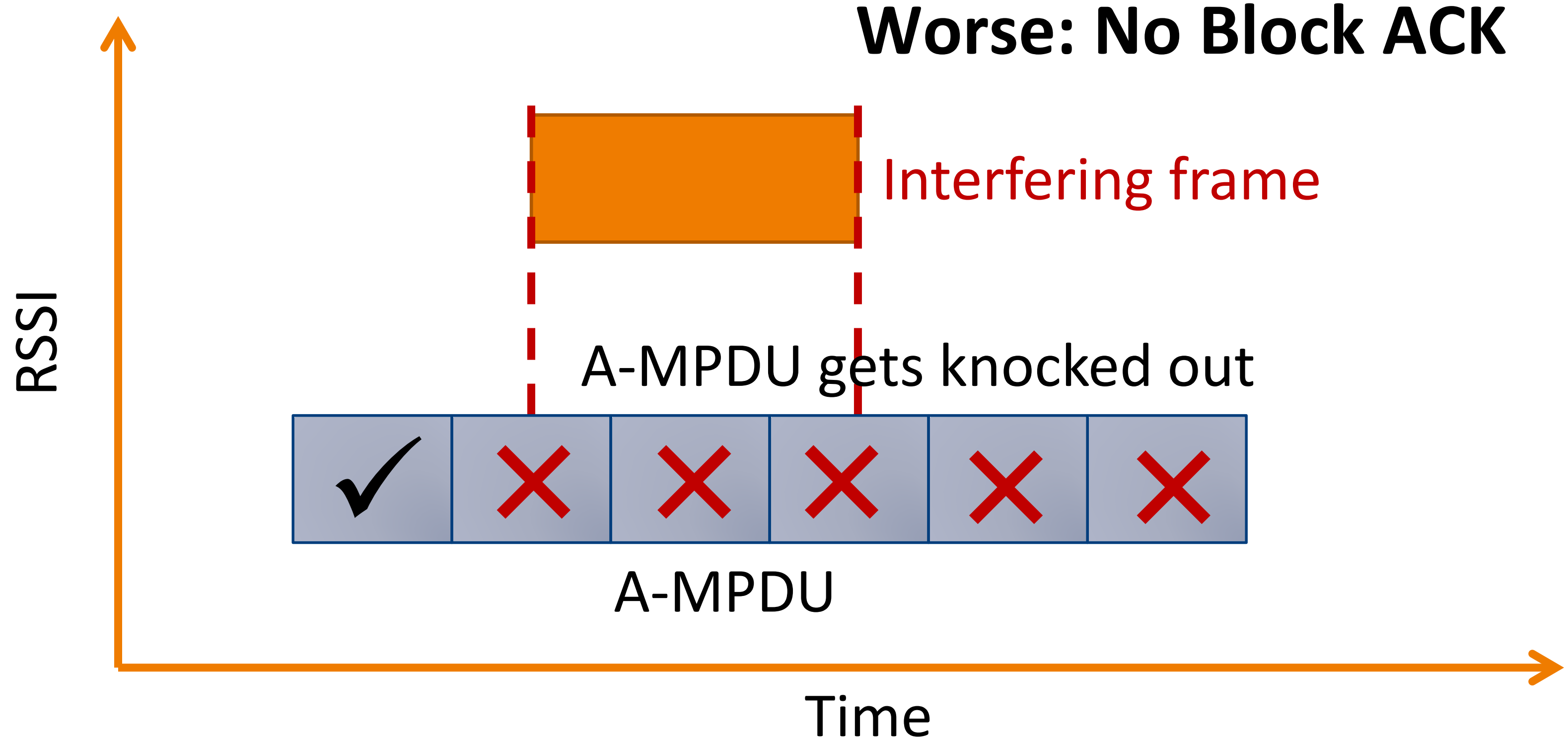
Without MiM RX: 3 Fail: 3



Key Insight: MiM can be harmful

Without MiM	RX: 3	Fail: 3
With MiM	RX: 1	Fail: 5

Worse: No Block ACK



Why Use A-MPDU?

- A-MPDU reduces TX overhead
- Maximum A-MPDU size
  - **64 KB** for 11n (equivalent to 40+ frames)
  - **1 MB** for 11ac (600+ frames)
- A tiny interfering frame (e.g. ACK) can destroy the whole A-MPDU

How Bad is it?

SOMETIMES GOOD, SOMETIMES BAD

What Can We Do?

HOW TO EFFECTIVELY USE MIM

Our Contributions

1. How bad is it?

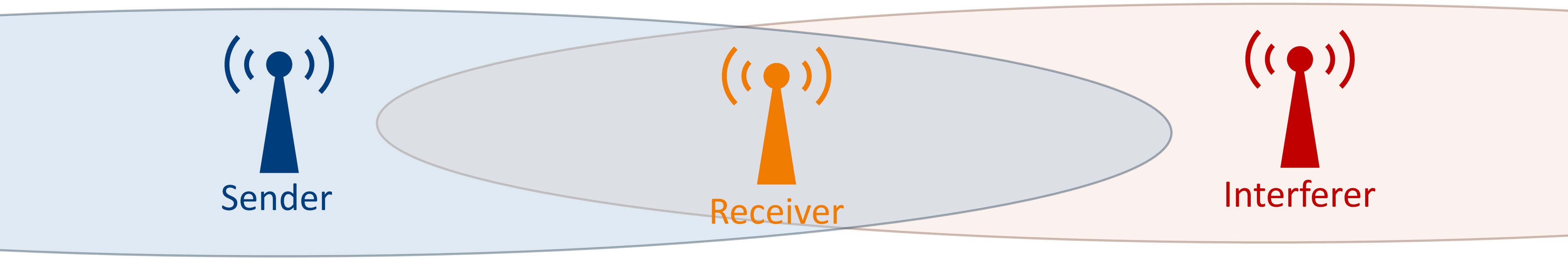
A: Study the impact of MiM on A-MPDUs

2. What can we do?

A: Adaptive algorithm to enable/disable MiM

Studying the Impact of MiM

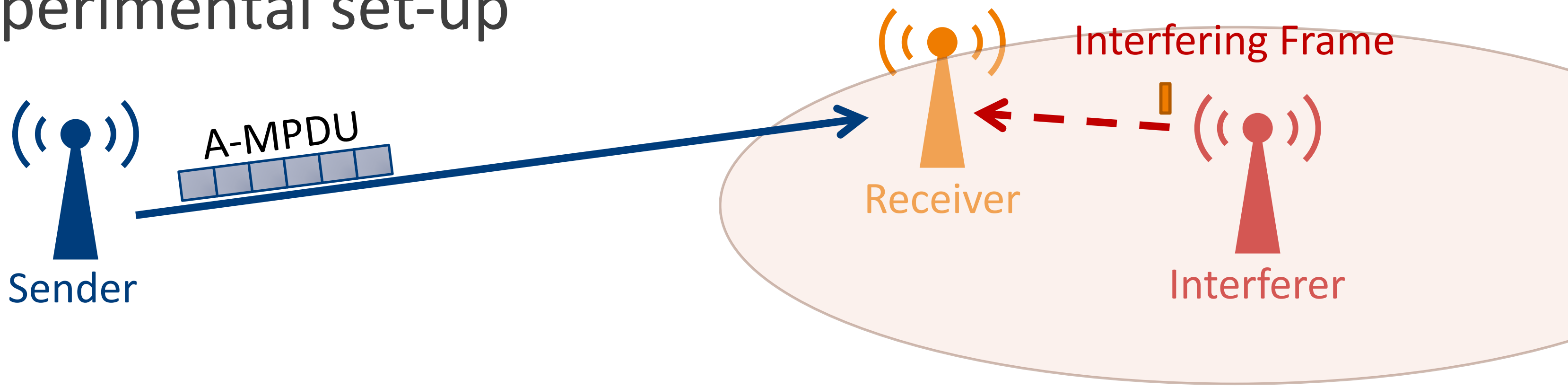
Experimental set-up



- Sender & Interferer out-of-range
- Receiver closer to Interferer

Studying the Impact of MiM

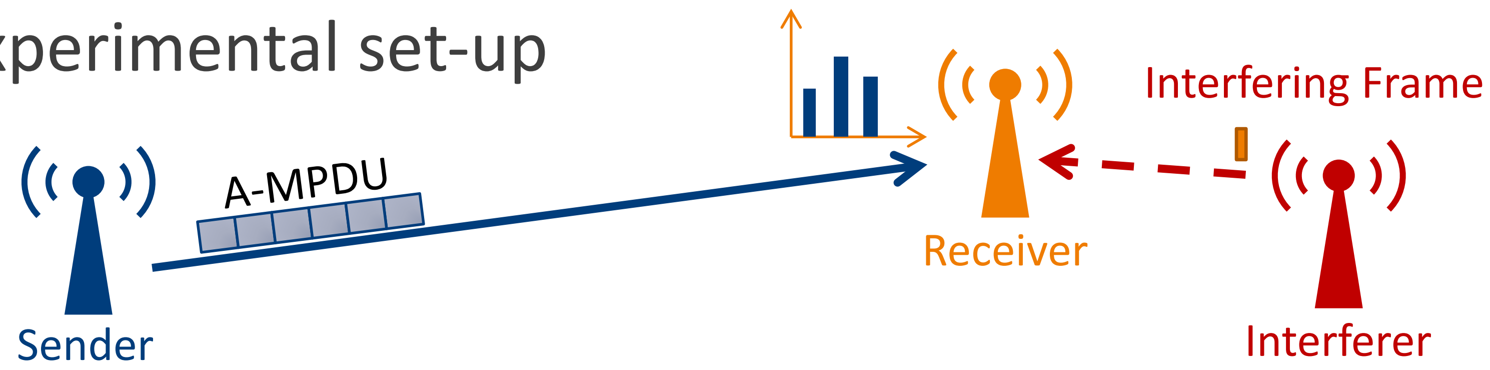
Experimental set-up



- Sender & Interferer out-of-range
- Receiver closer to Interferer
- Sender sends an A-MPDU (w/o MAC retry)
- Interferer broadcast an Interfering Frame

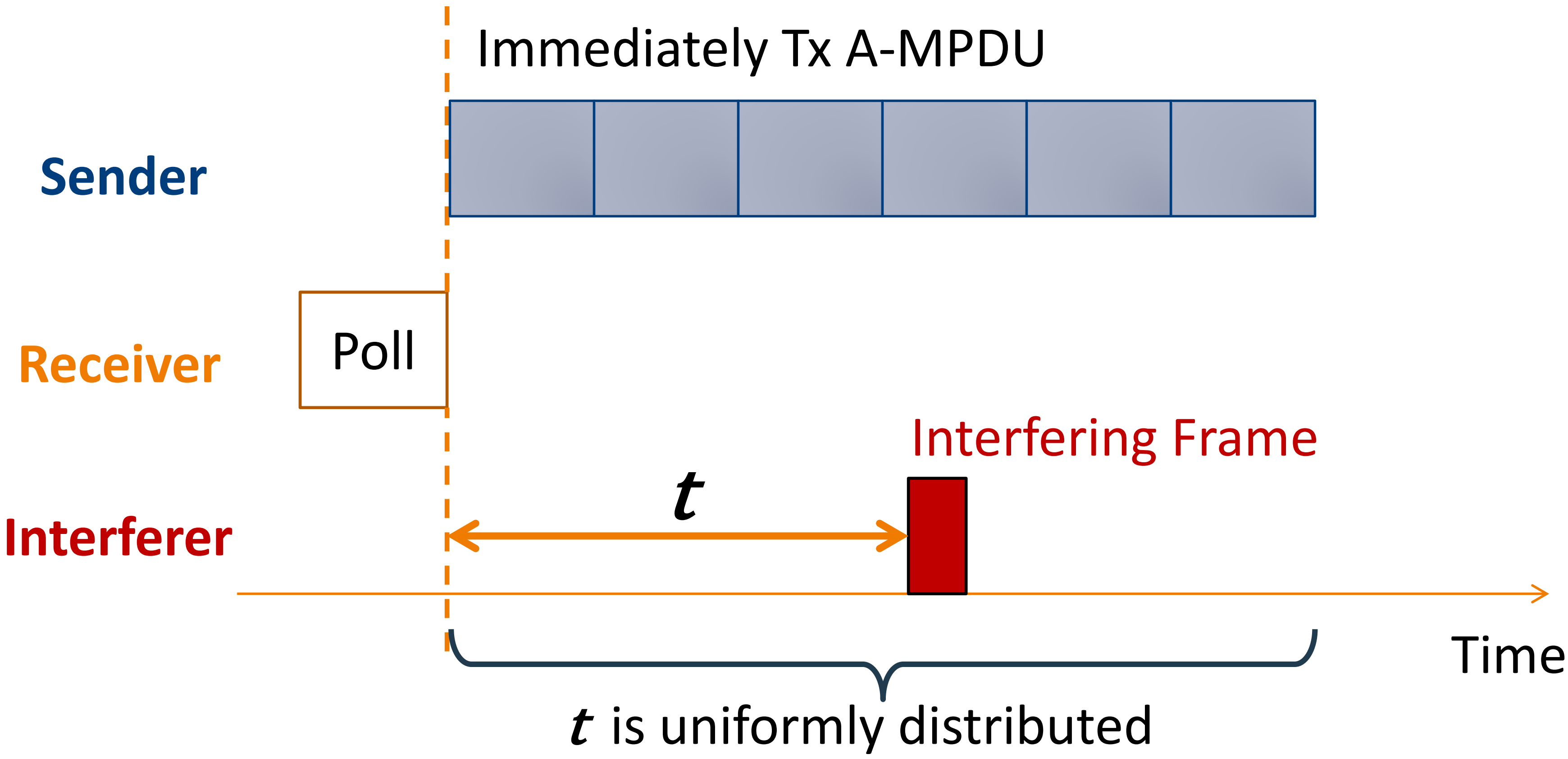
Studying the Impact of MiM

Experimental set-up



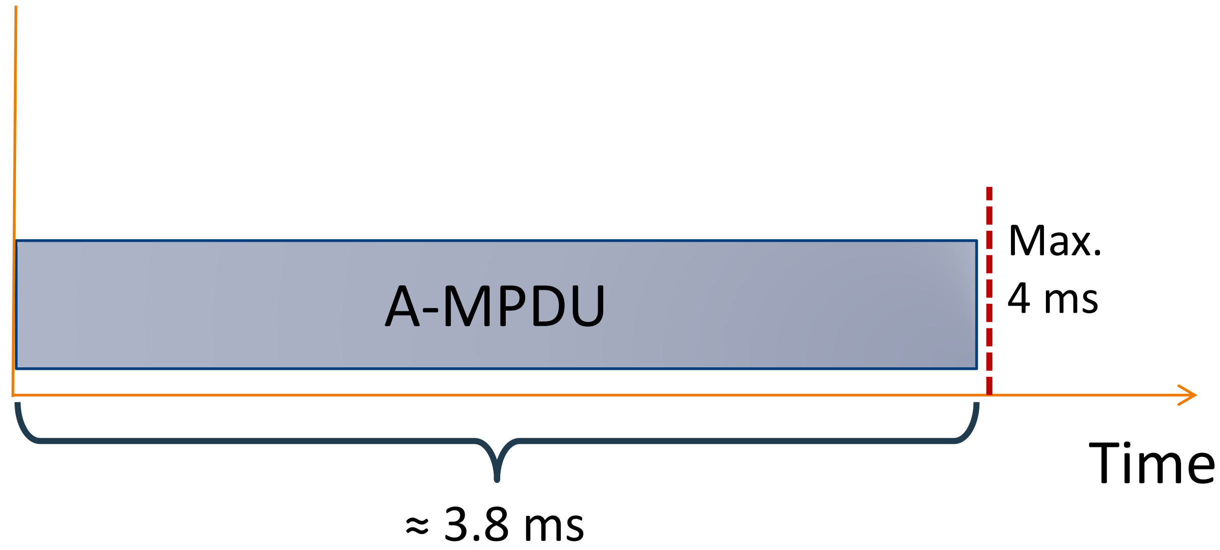
- Sender & Interferer out-of-range
- Receiver closer to Interferer
- Sender sends an A-MPDU (w/o MAC retry)
- Interferer broadcast an Interfering Frame
- Measure FDR

Ensure collision



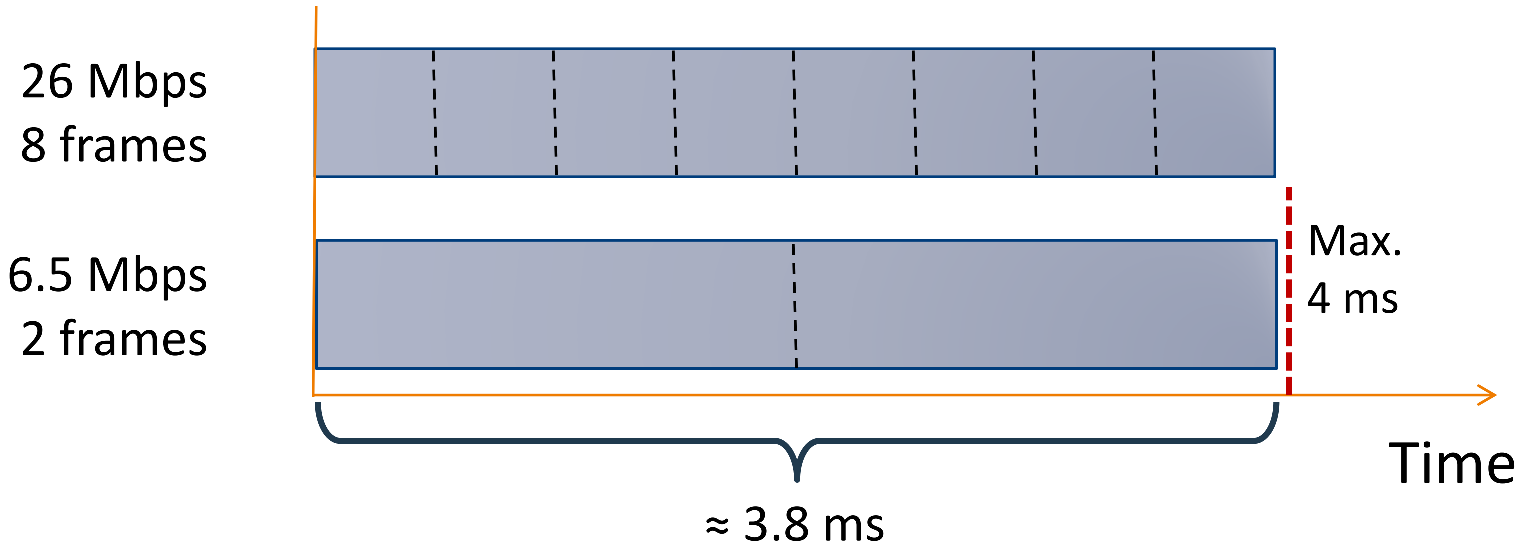
Duration of A-MPDU

Max duration limited by ath9k driver



Size of A-MPDU (# frames)

Depends on data rate



MCS Index	0	1	2	3	4	5	6	7
Data Rate (Mbps)	6.5	13	19.5	26	39	52	58.5	65
Frames	2	4	6	8	12	16	18	20

The Detrimental Impact of MiM

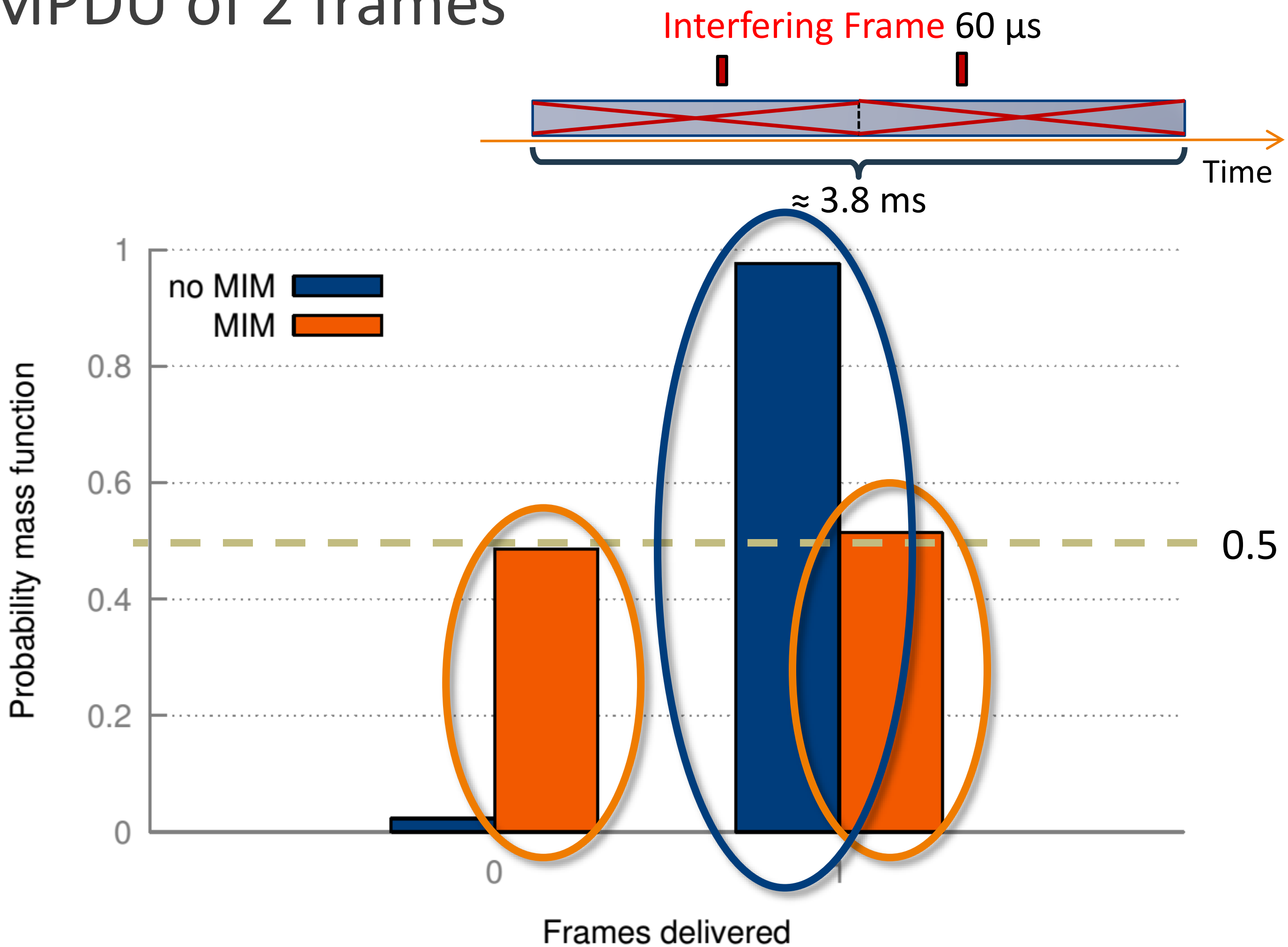
1. Size of A-MPDU
    - # Frames per A-MPDU
2. Length of Interference Frame
    - Air-time duration
3. Channel Bonding
    - Using adjacent channels

1. Size of A-MPDU?

NUMBER OF FRAMES IN AN A-MPDU

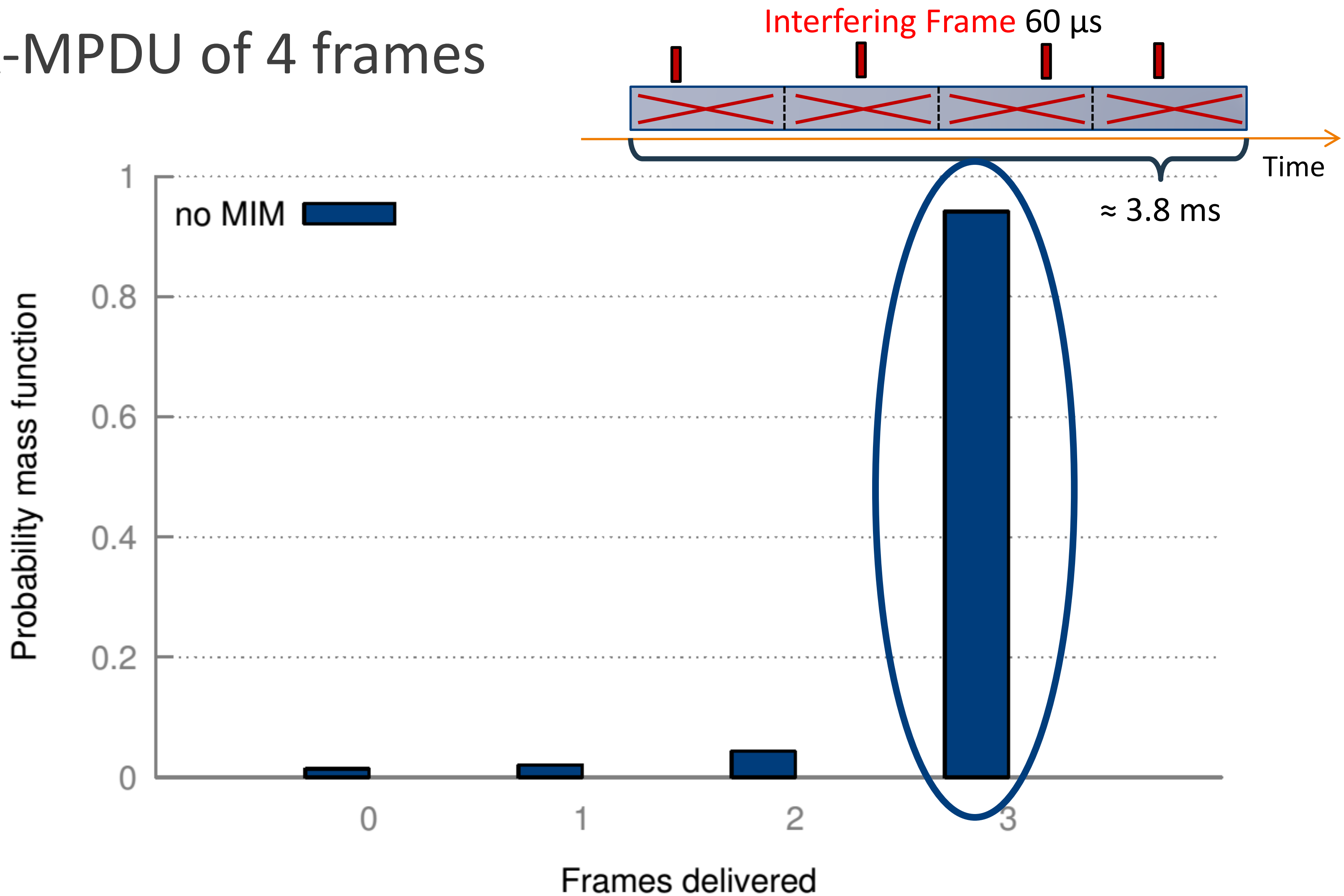
Impact of A-MPDU size

A-MPDU of 2 frames



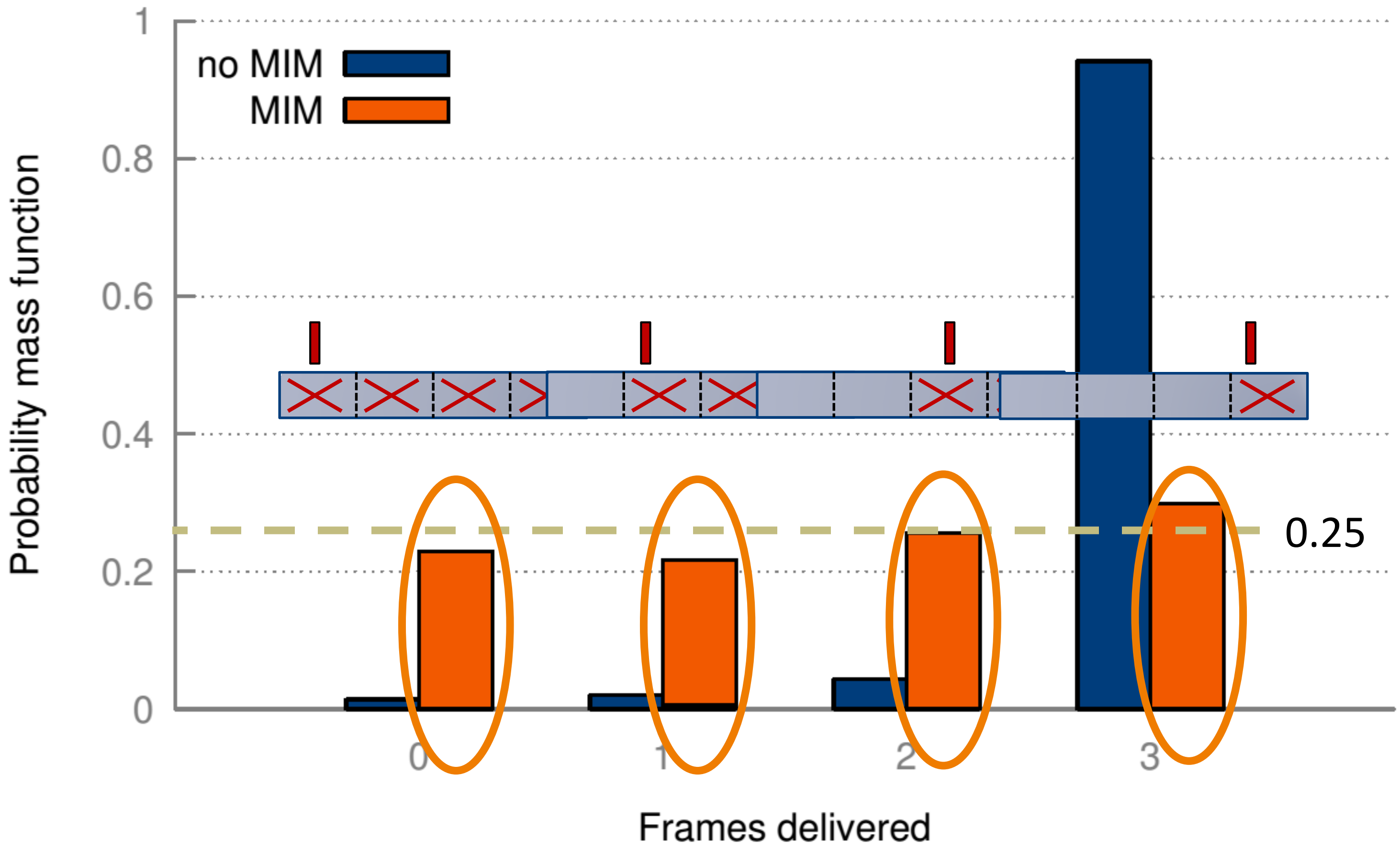
Impact of A-MPDU size

A-MPDU of 4 frames



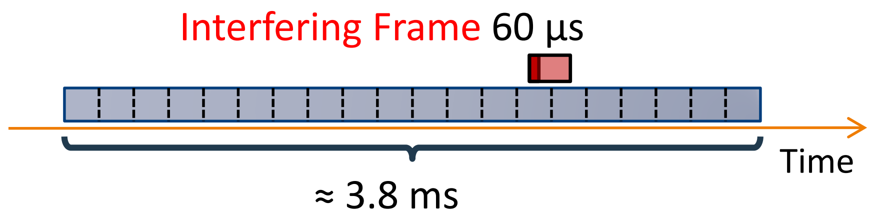
Impact of A-MPDU size

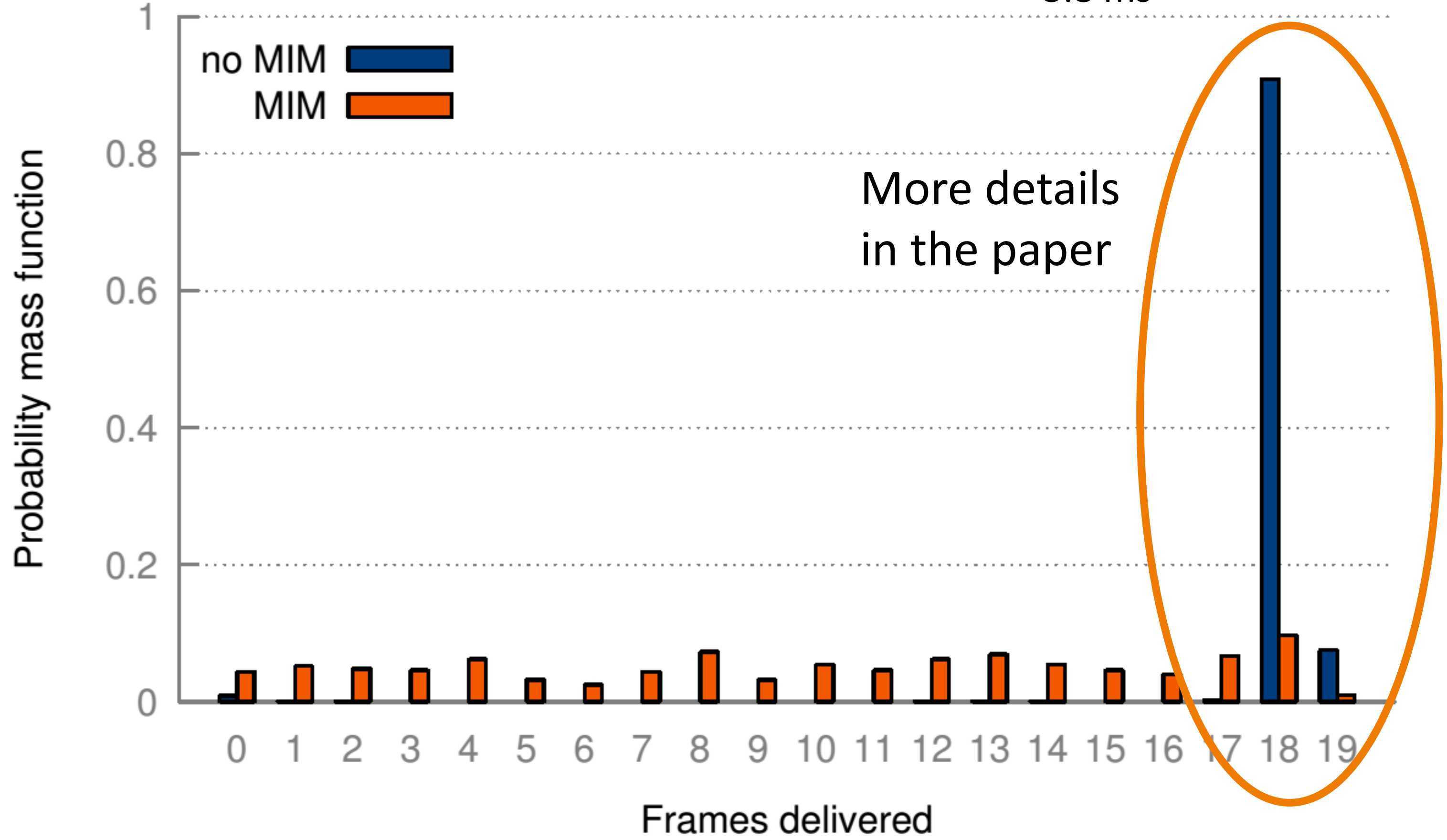
A-MPDU of 4 frames



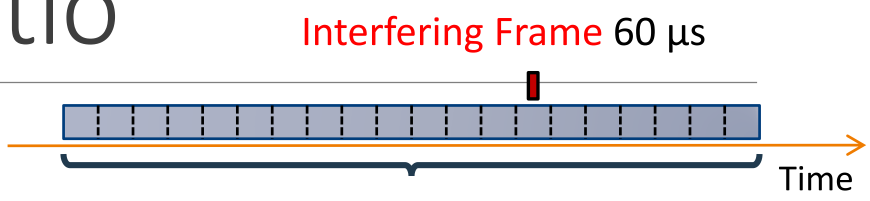
Impact of A-MPDU size

A-MPDU of 20 frames

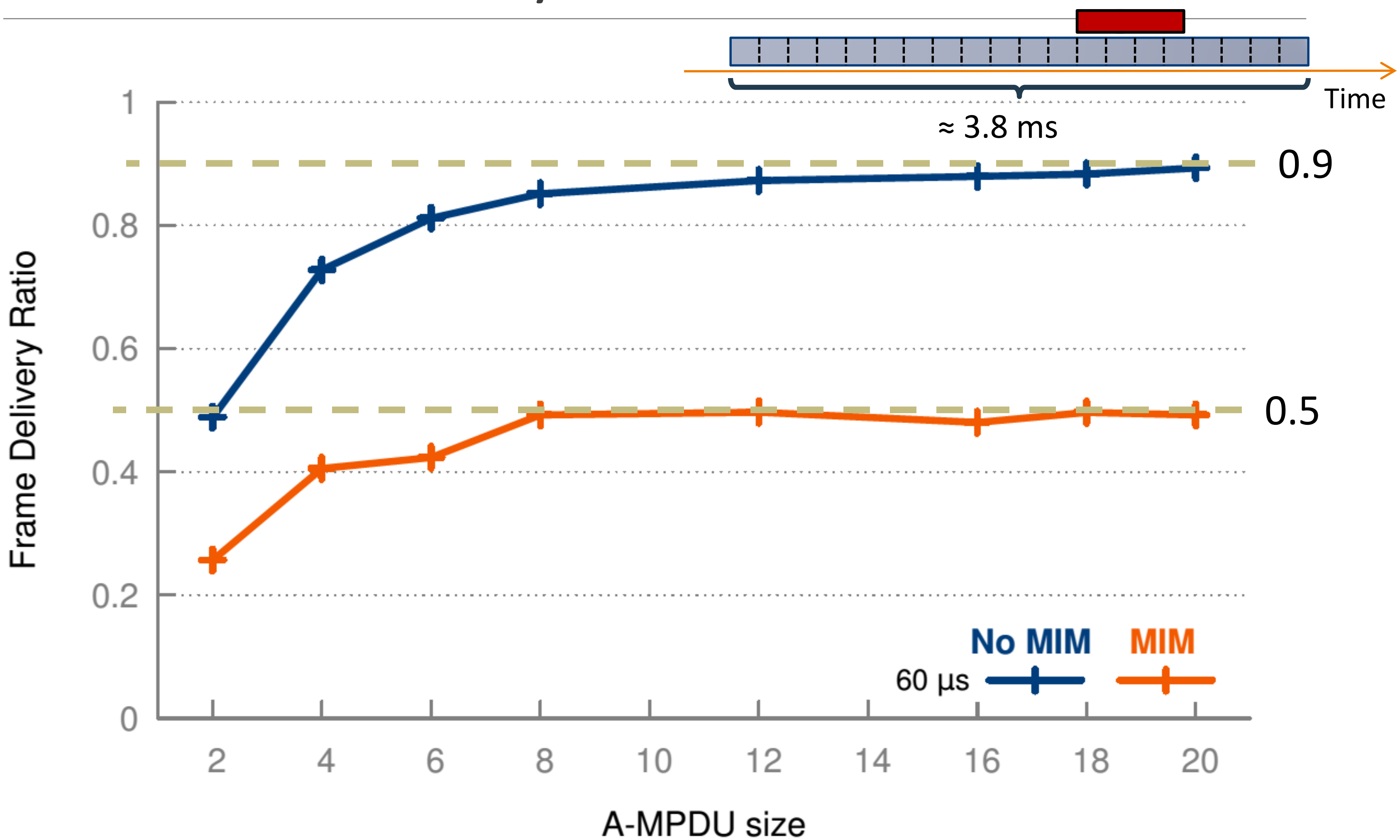




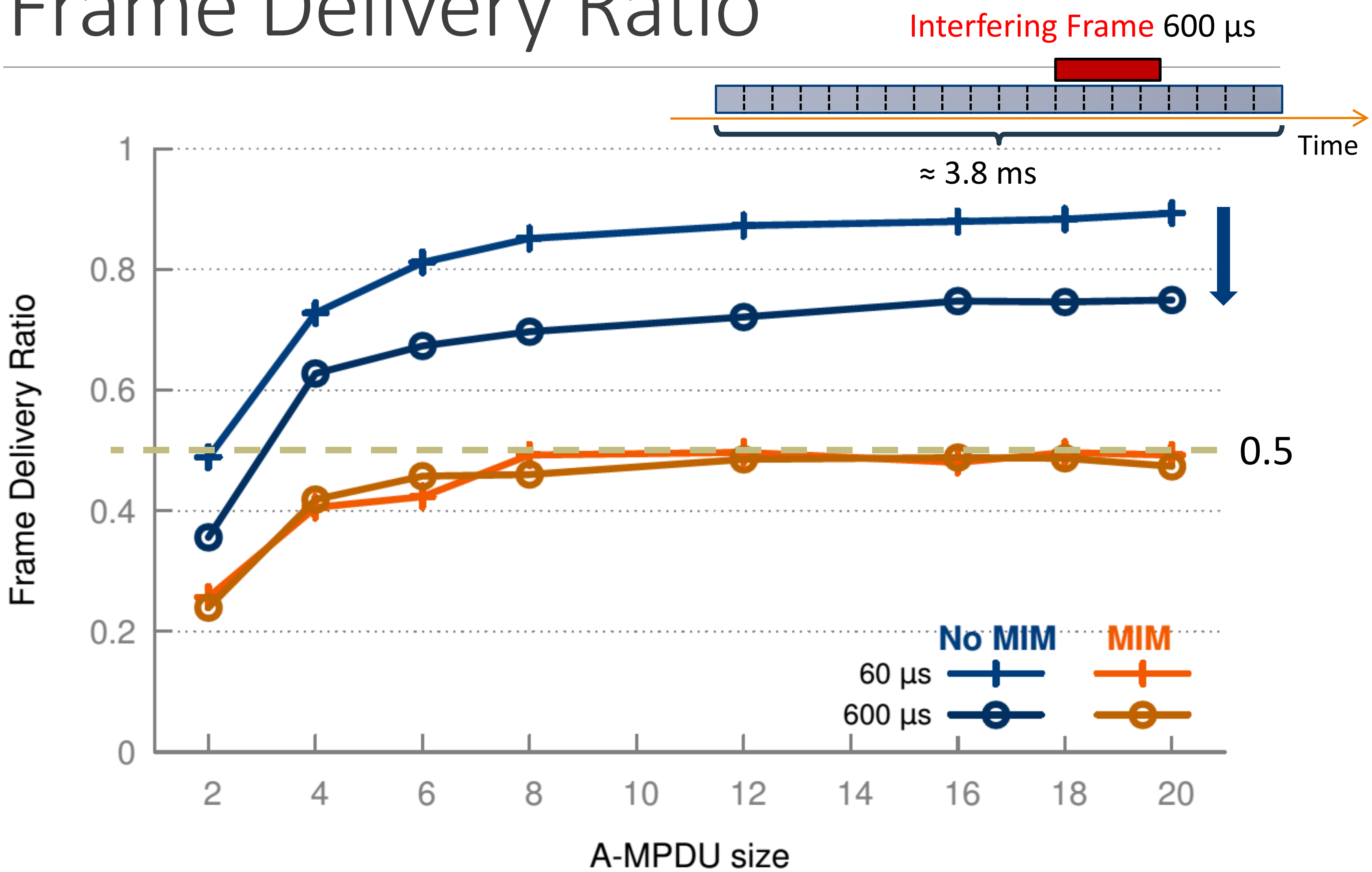
Frame Delivery Ratio



Frame Delivery Ratio



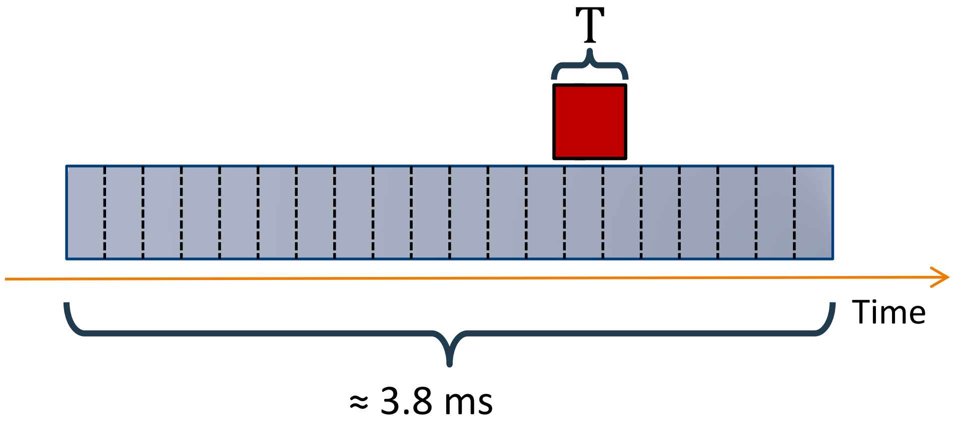
Frame Delivery Ratio



2. Length of Interference Frame

THE AIR-TIME DURATION

Air-time of Interfering Frames

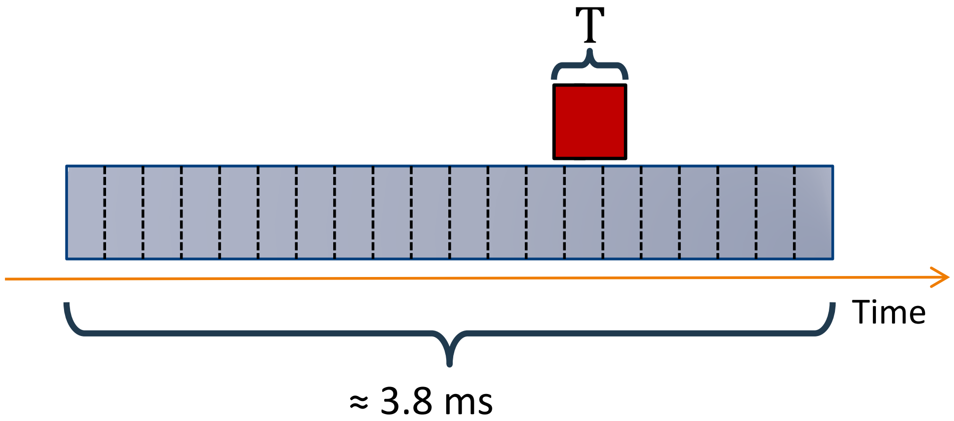


Intuition:

Without MiM, longer T → more frames loss

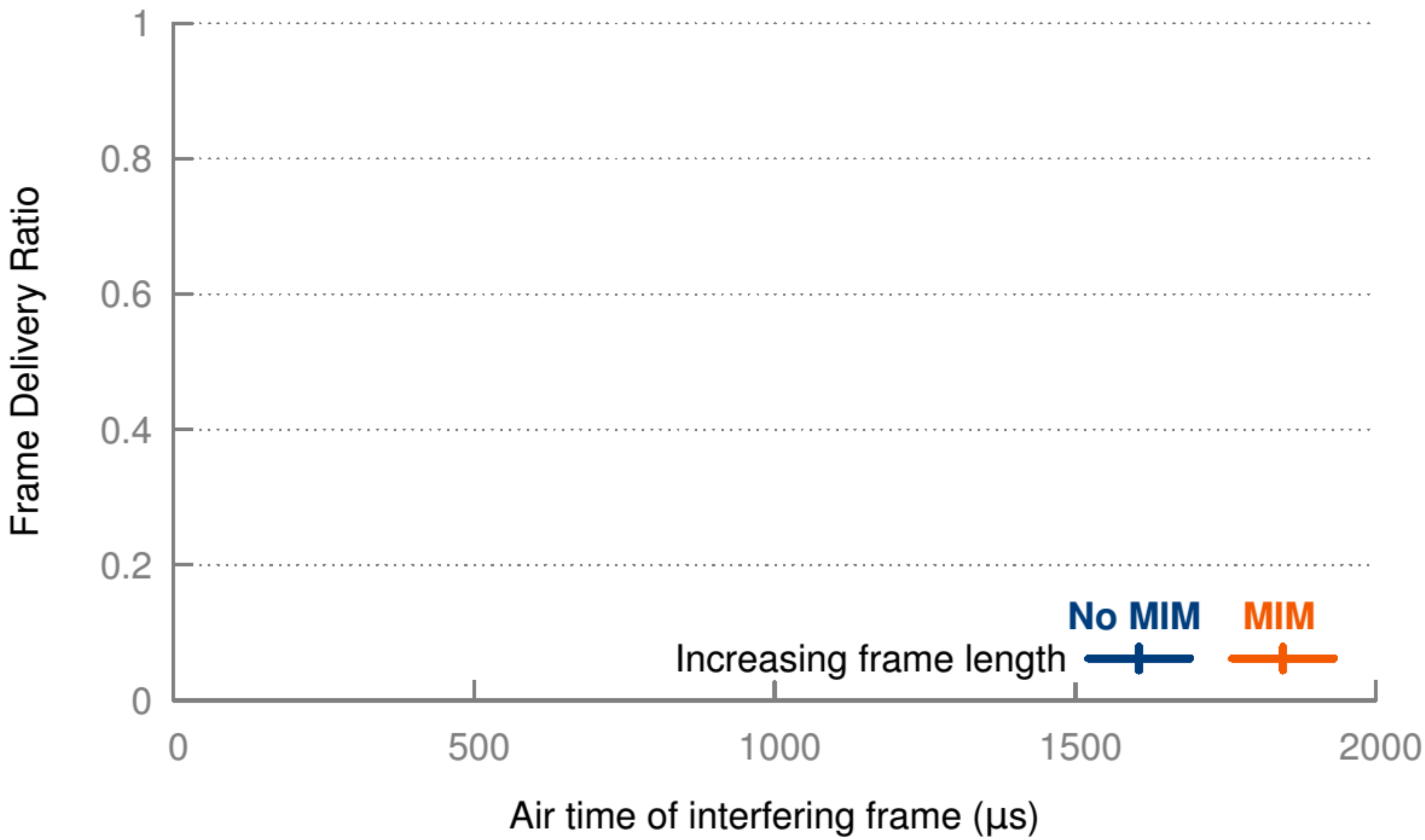
With MiM, T has no effect

How to set T

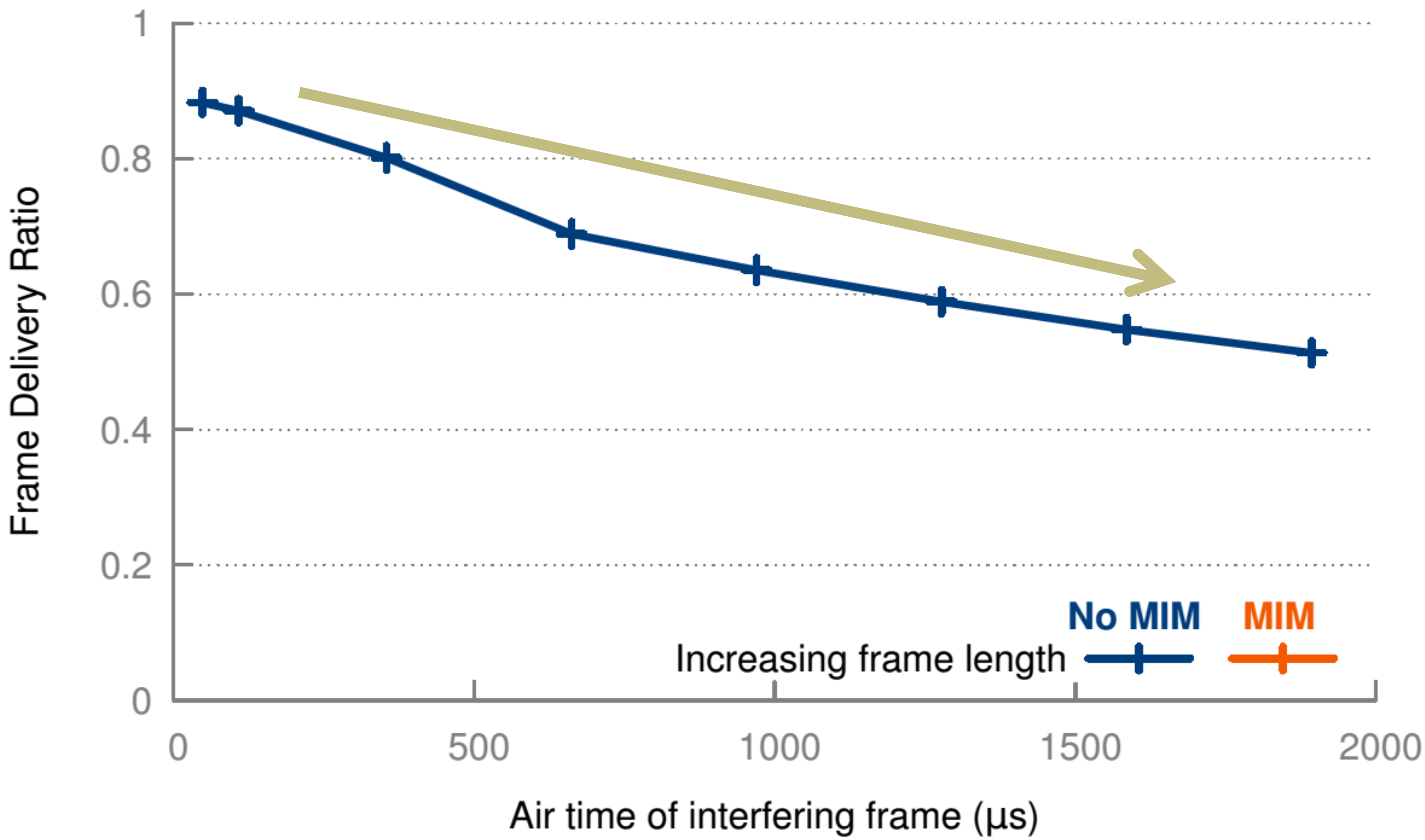


1. Vary frame length (# of bytes)
2. Vary data rate (bytes per sec)

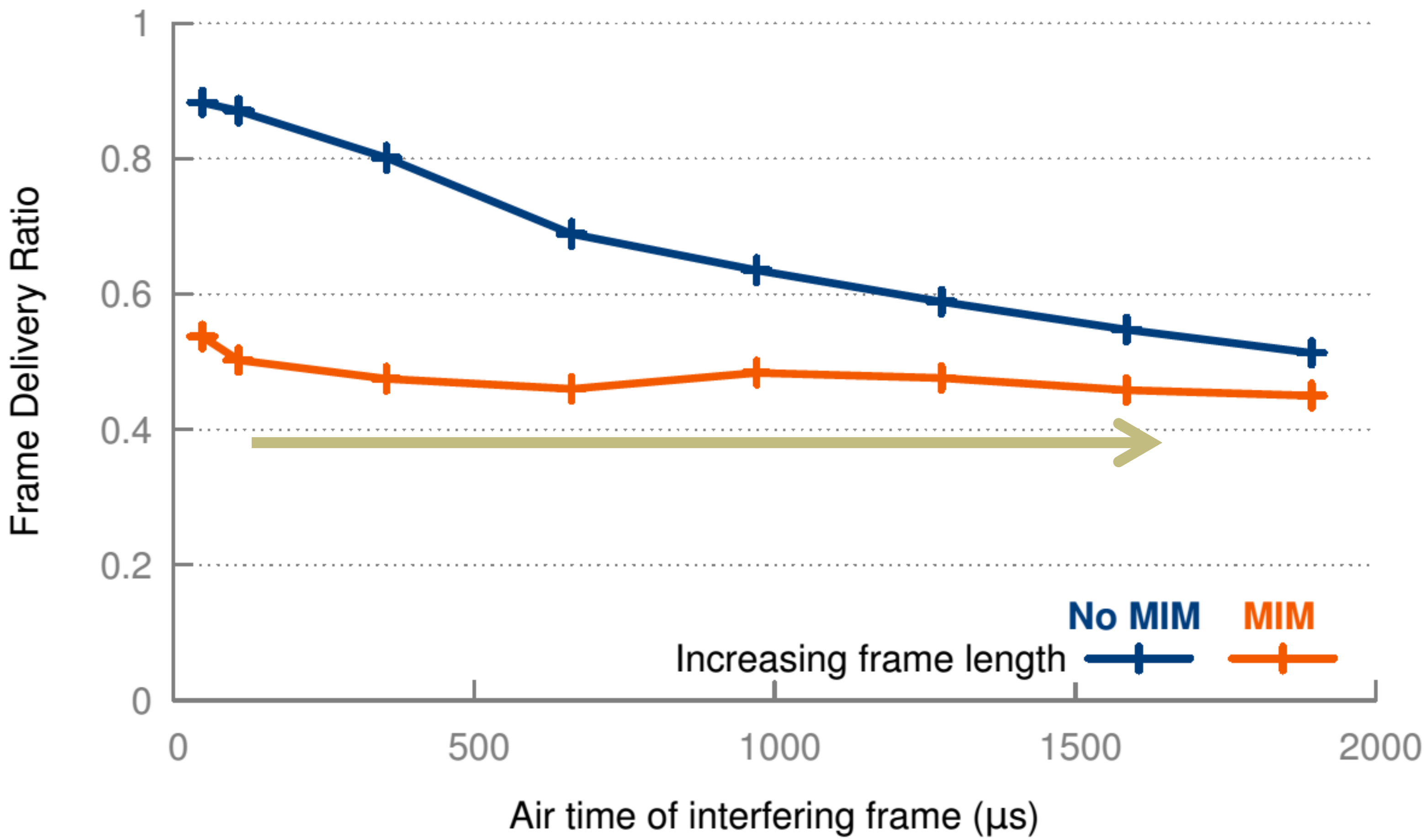
Increasing Frame Length



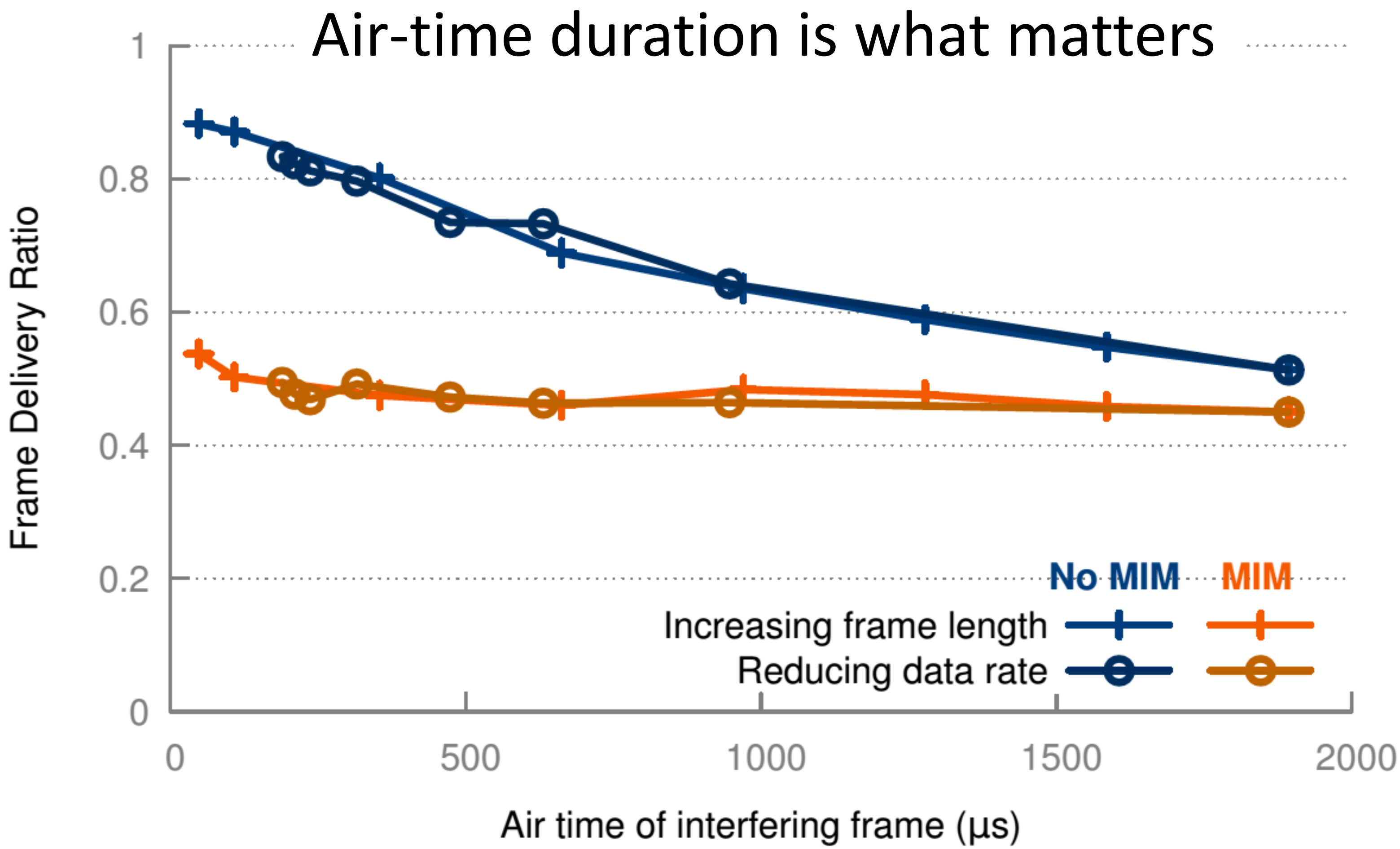
Increasing Frame Length



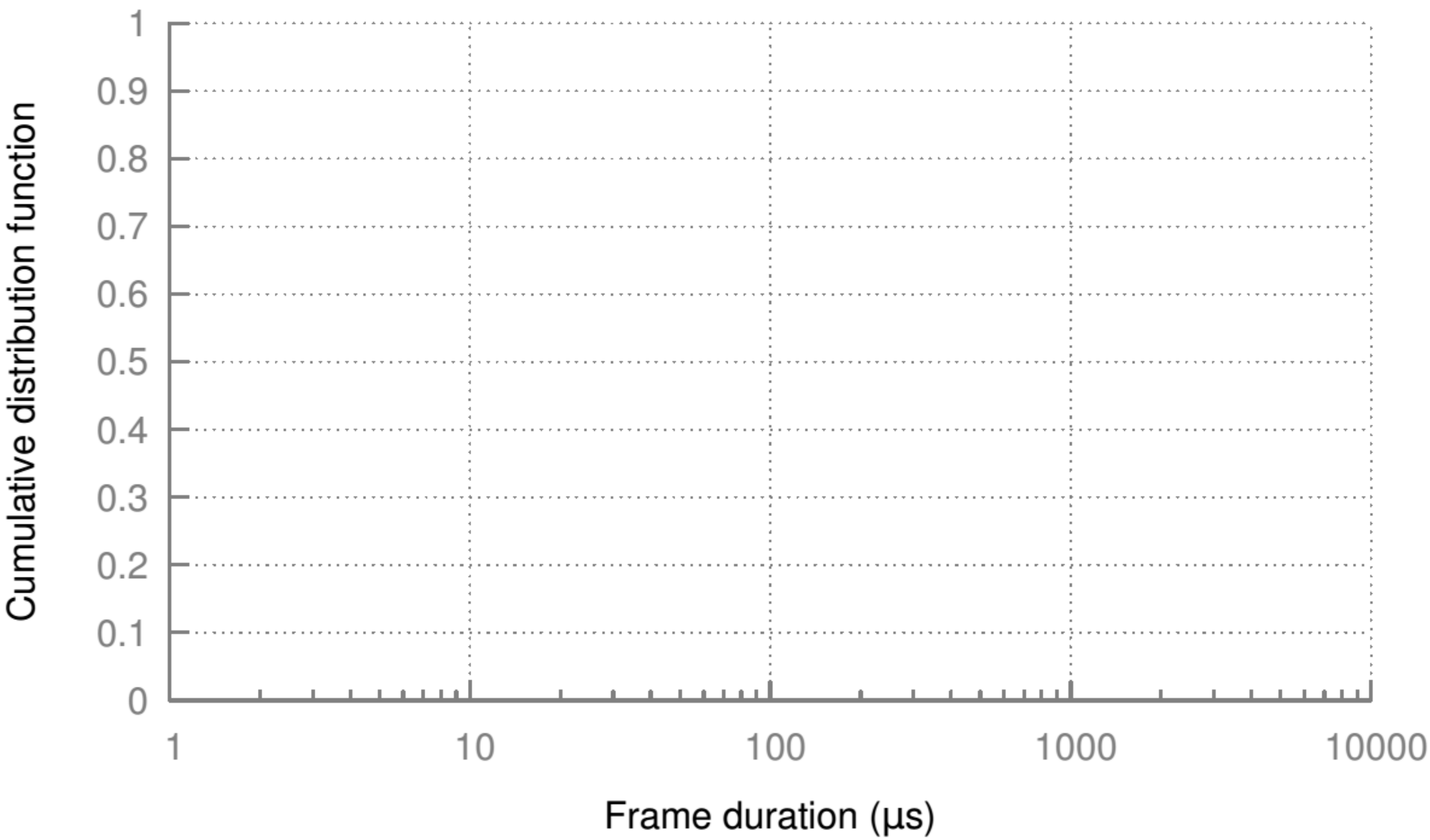
Increasing Frame Length



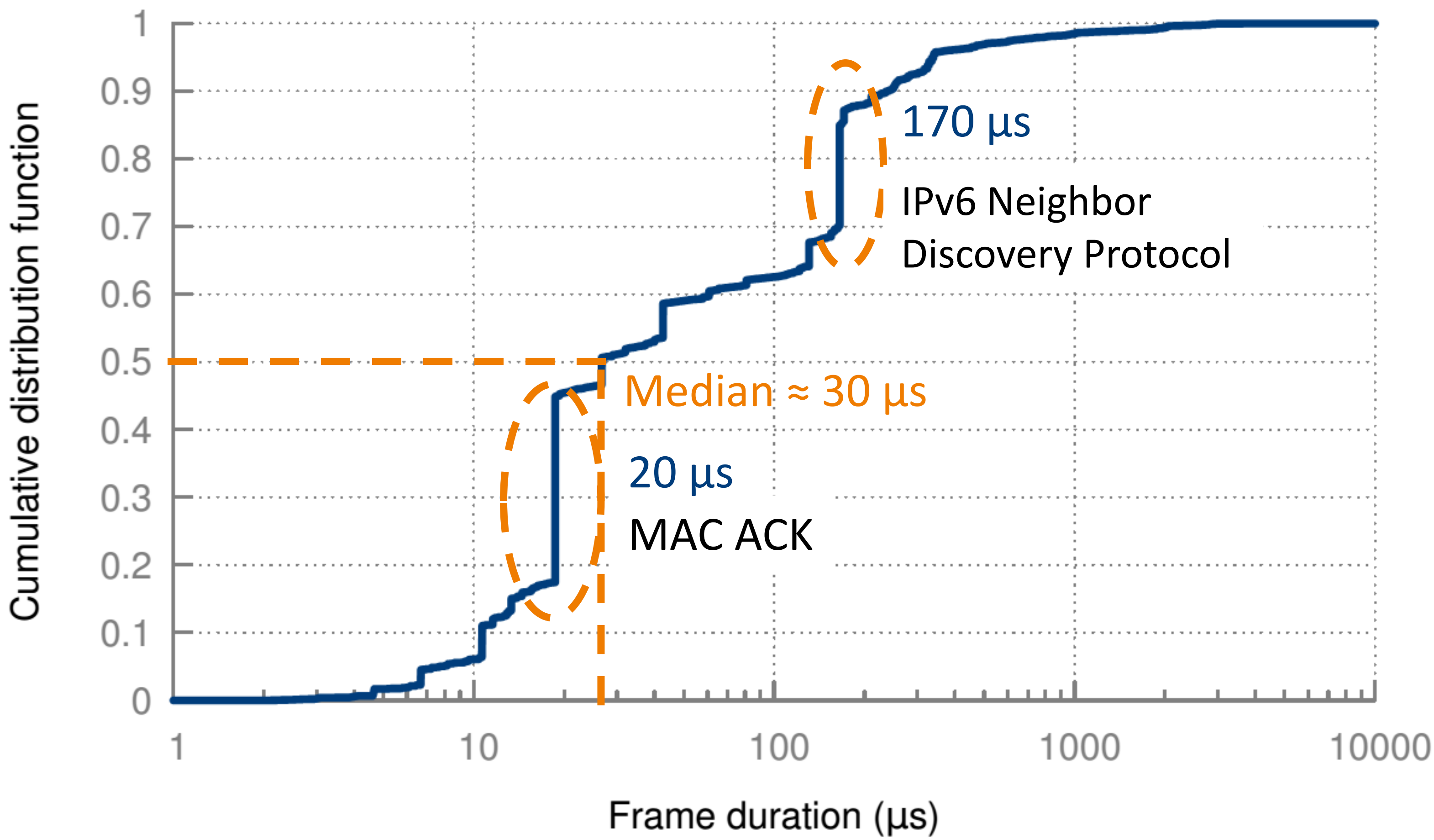
Increasing Data Rate



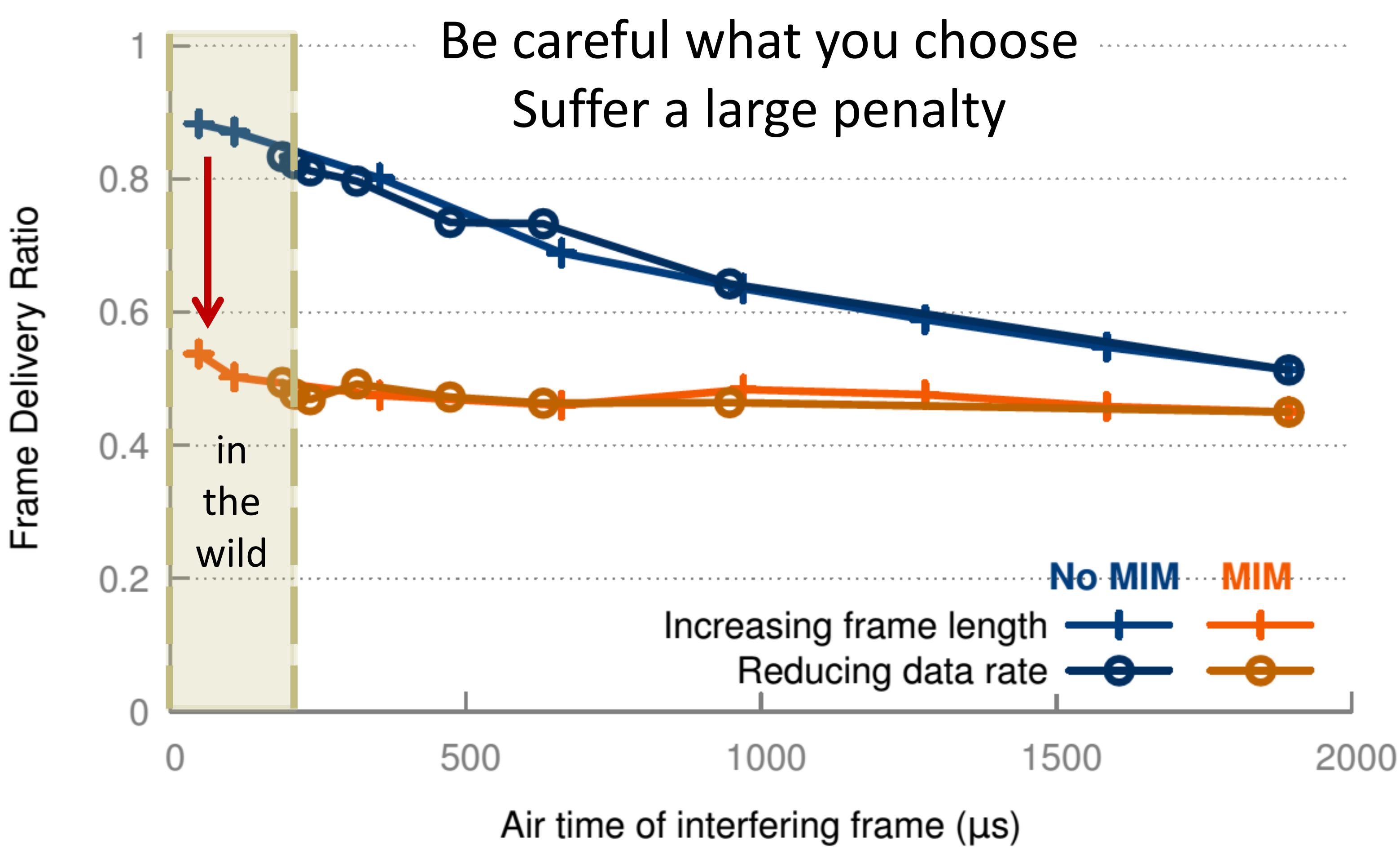
Air-time Duration… in the Wild



Air-time Duration… in the Wild



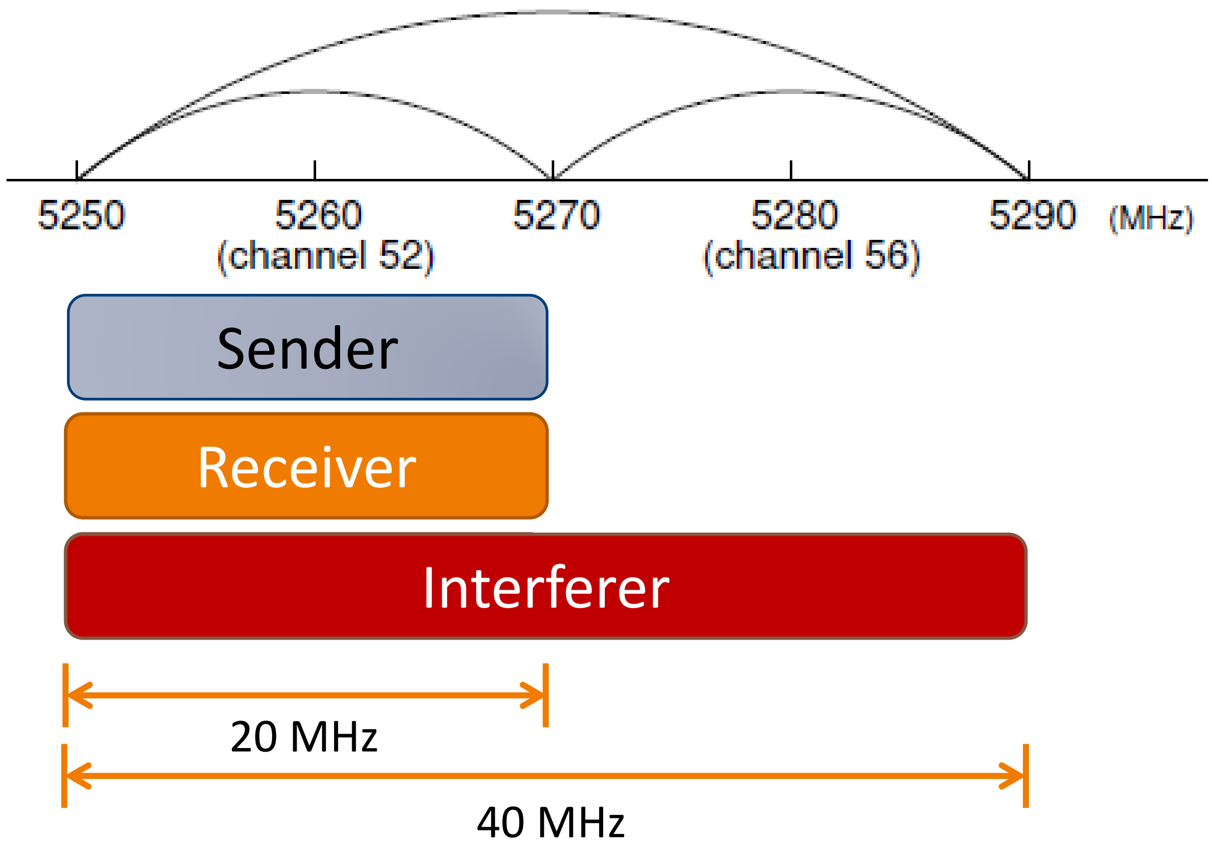
Putting it in Perspective



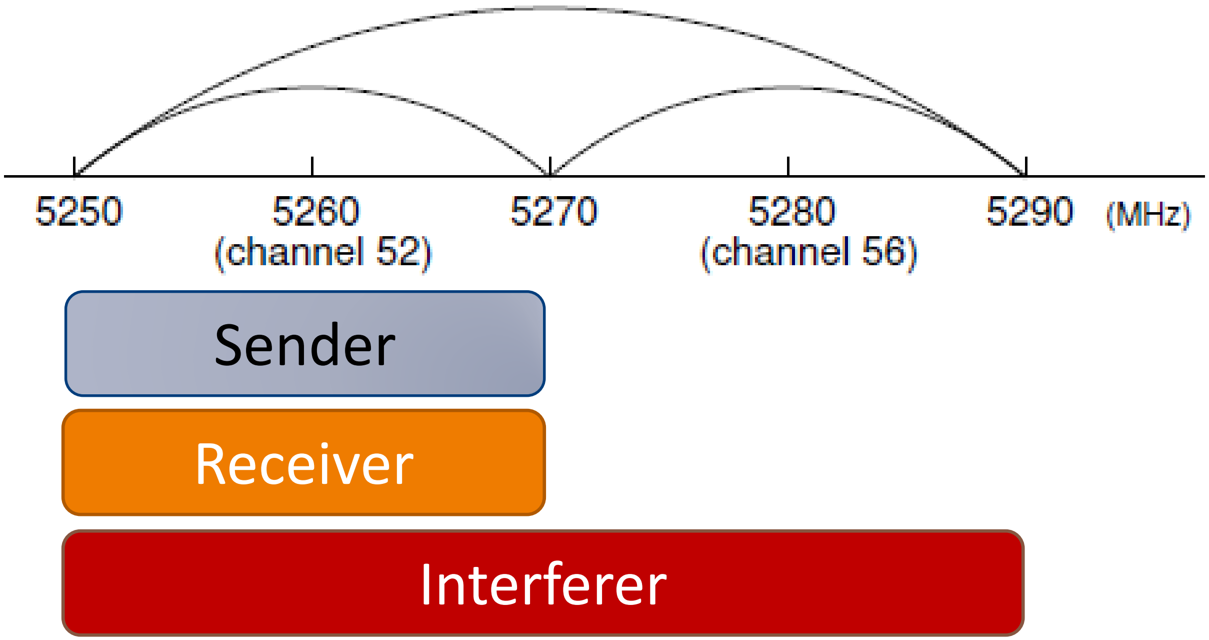
3. Channel Bonding

USING ADJACENT CHANNELS

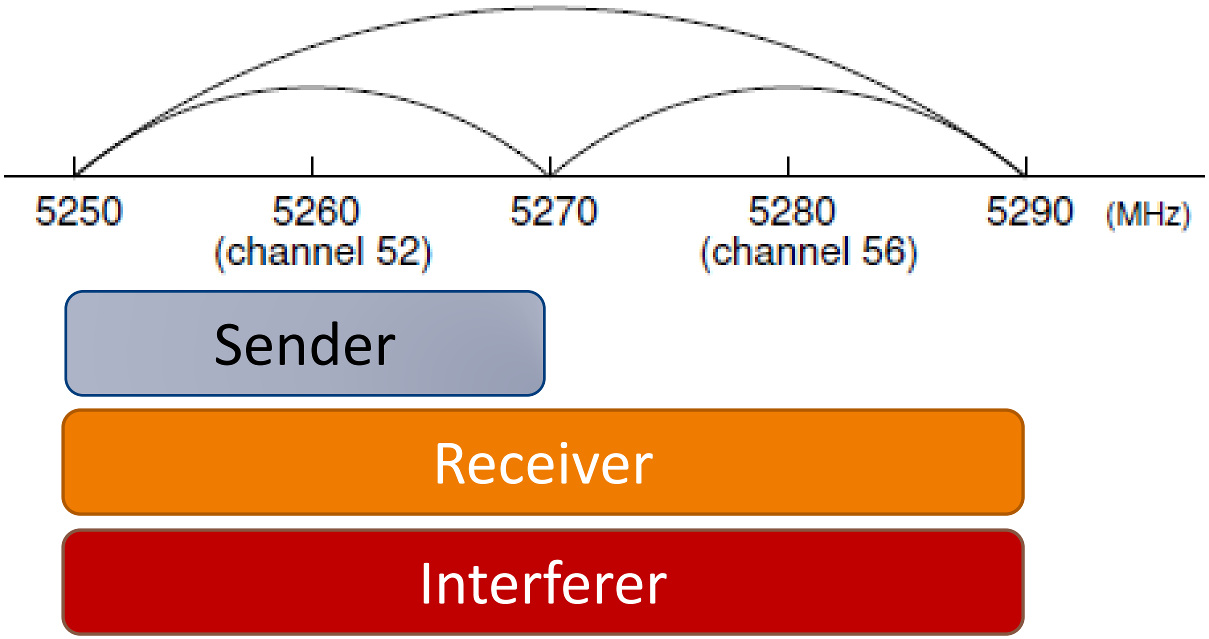
Channel bonding



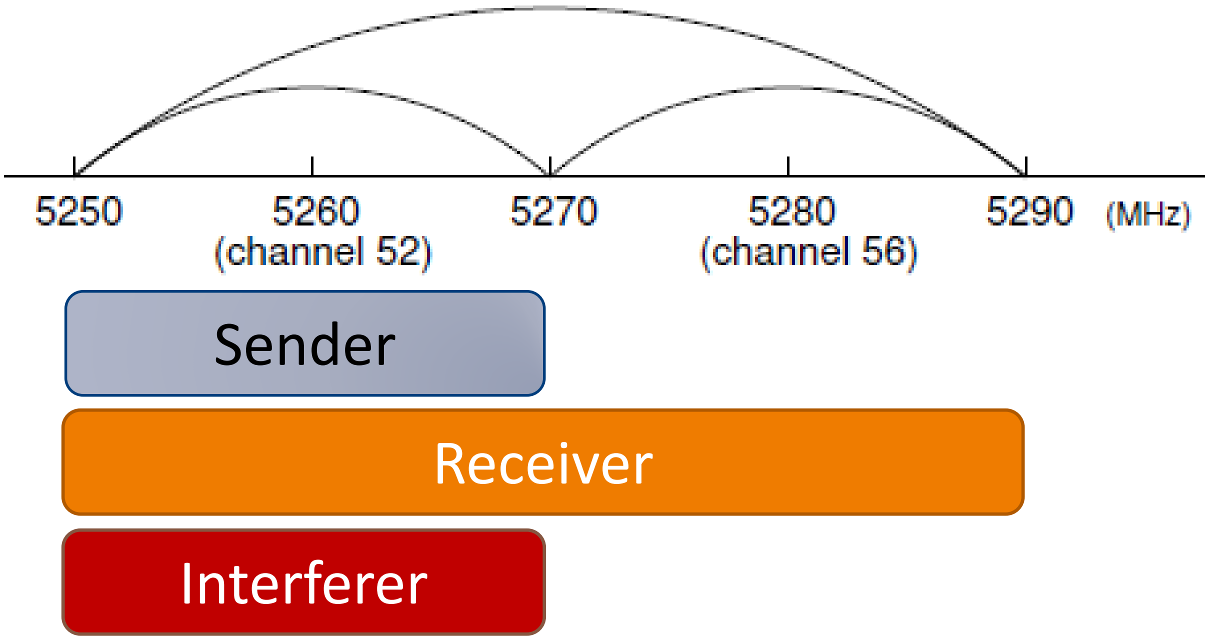
Channel bonding: Case 1



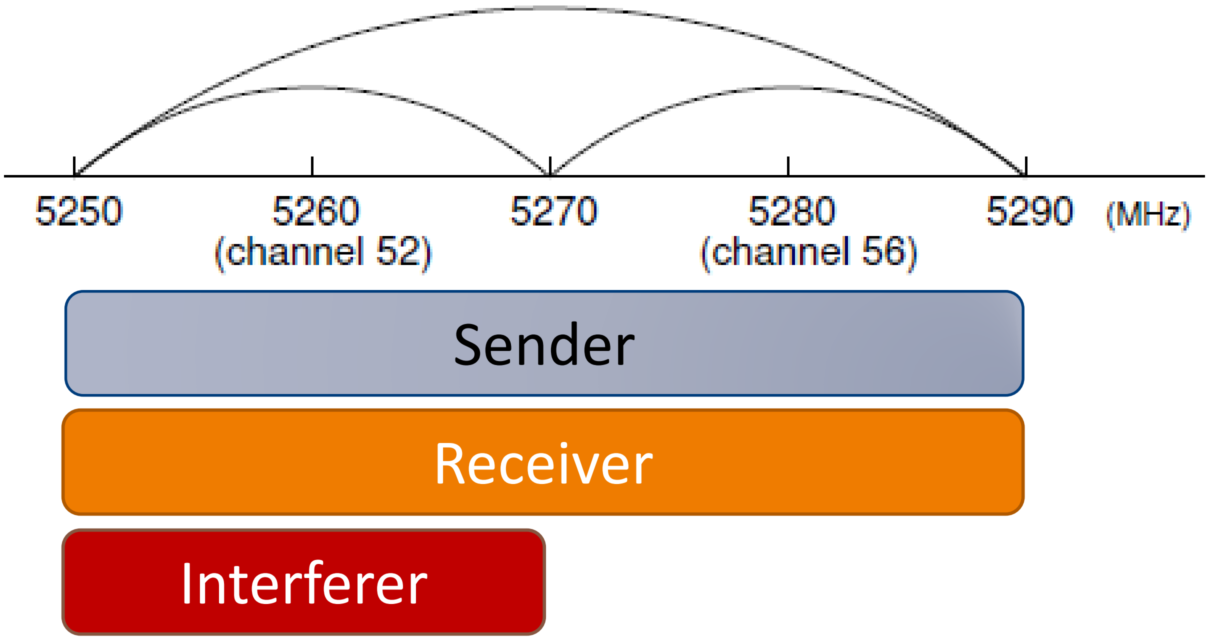
Channel bonding: Case 2



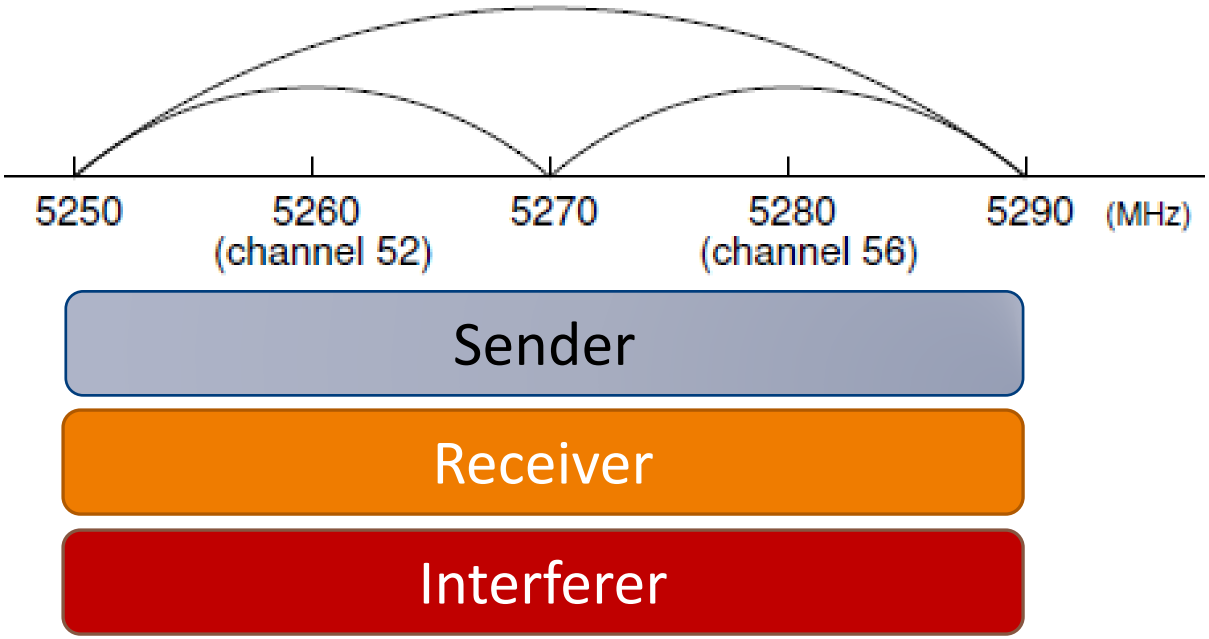
Channel bonding: Case 3



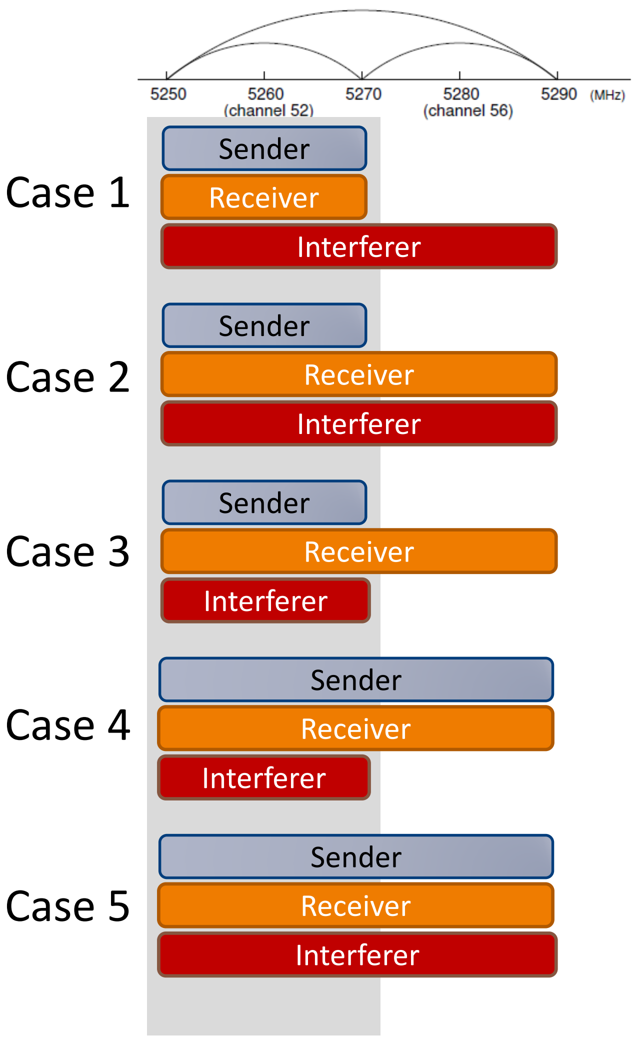
Channel bonding: Case 4



Channel bonding: Case 5



Channel bonding



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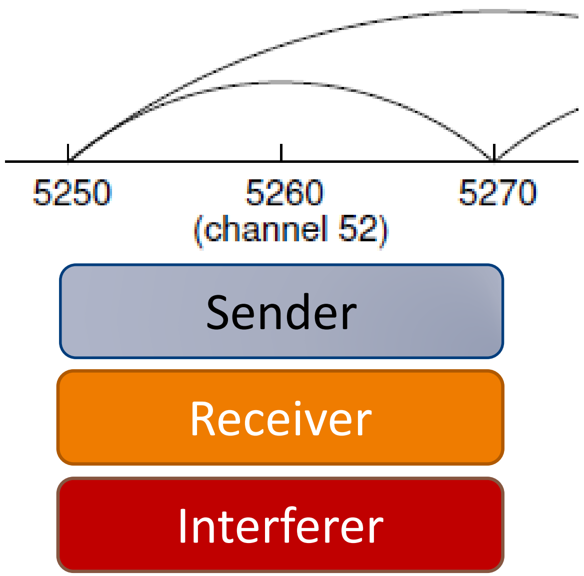
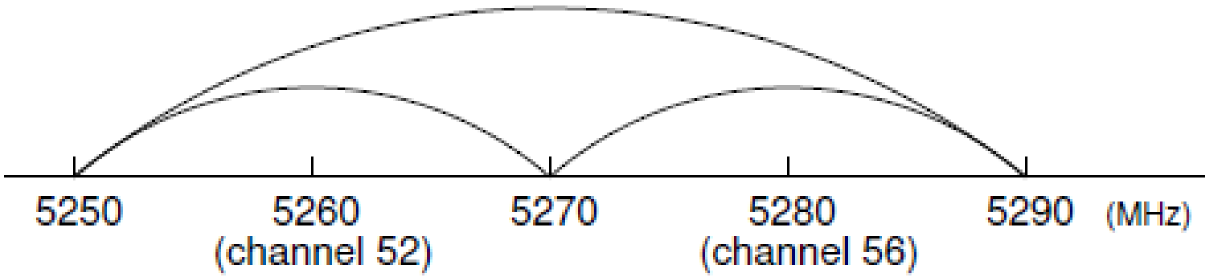


Adjacent Channel Interference

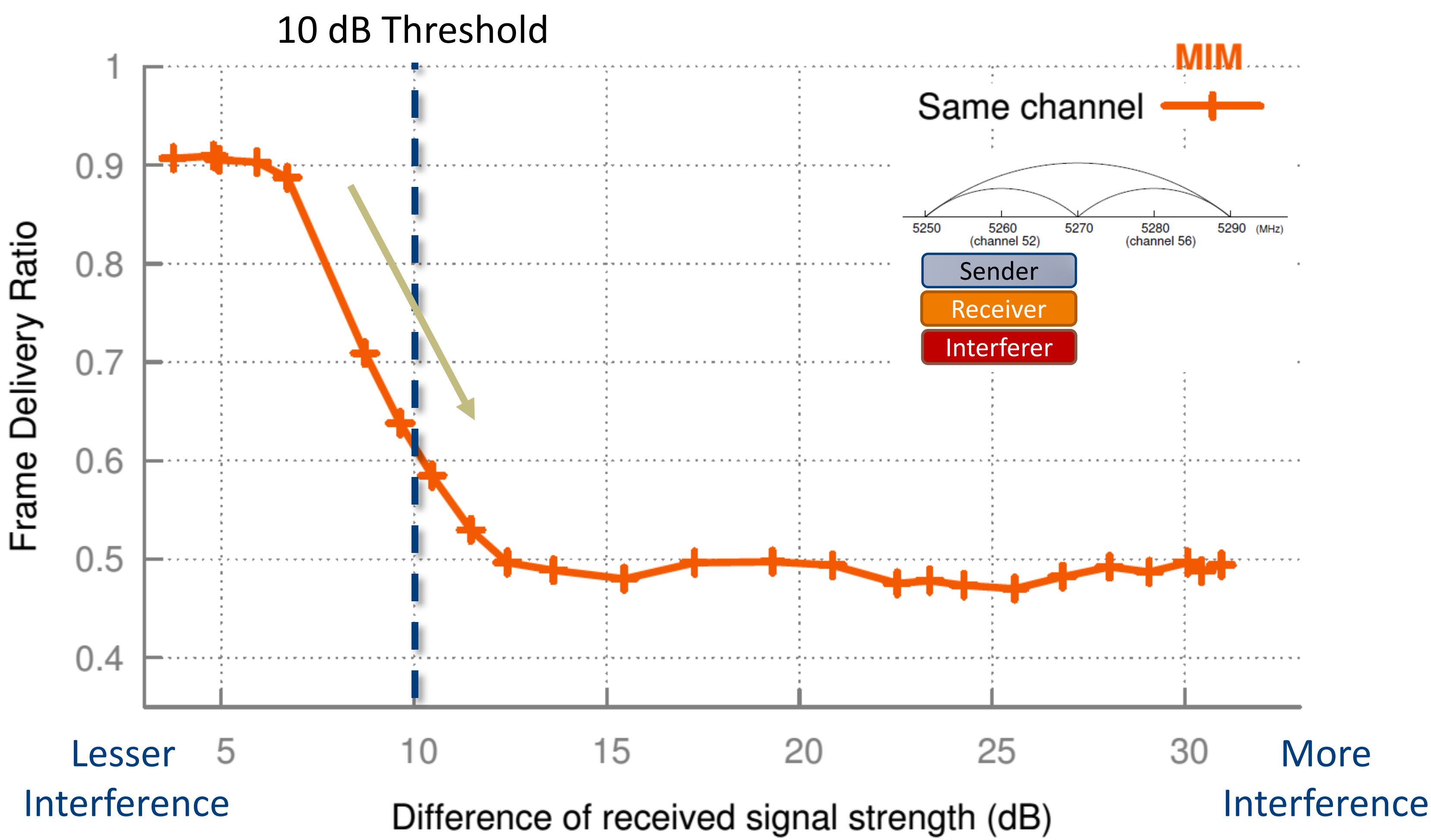


Sender

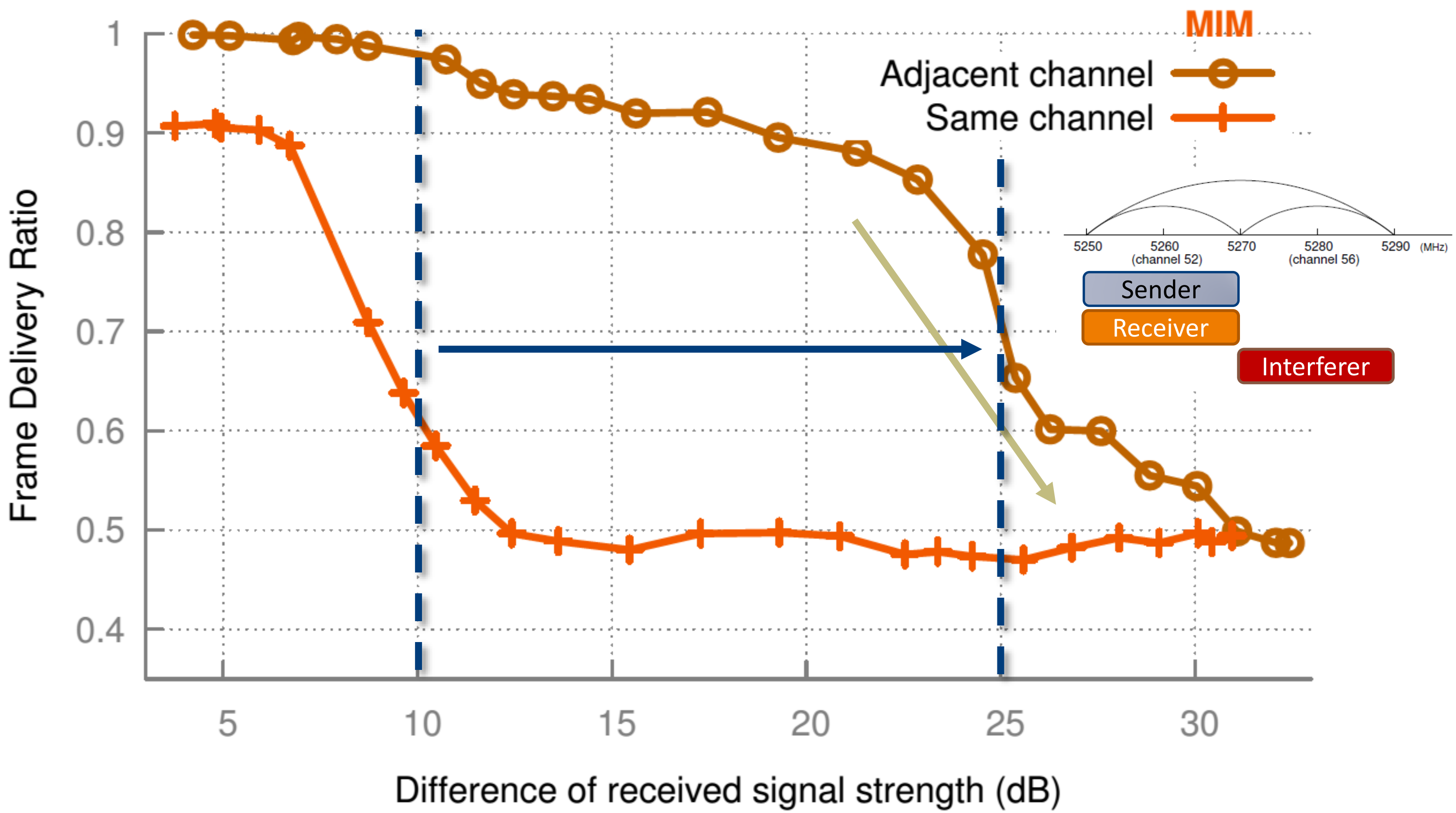
Receiver

Interferer

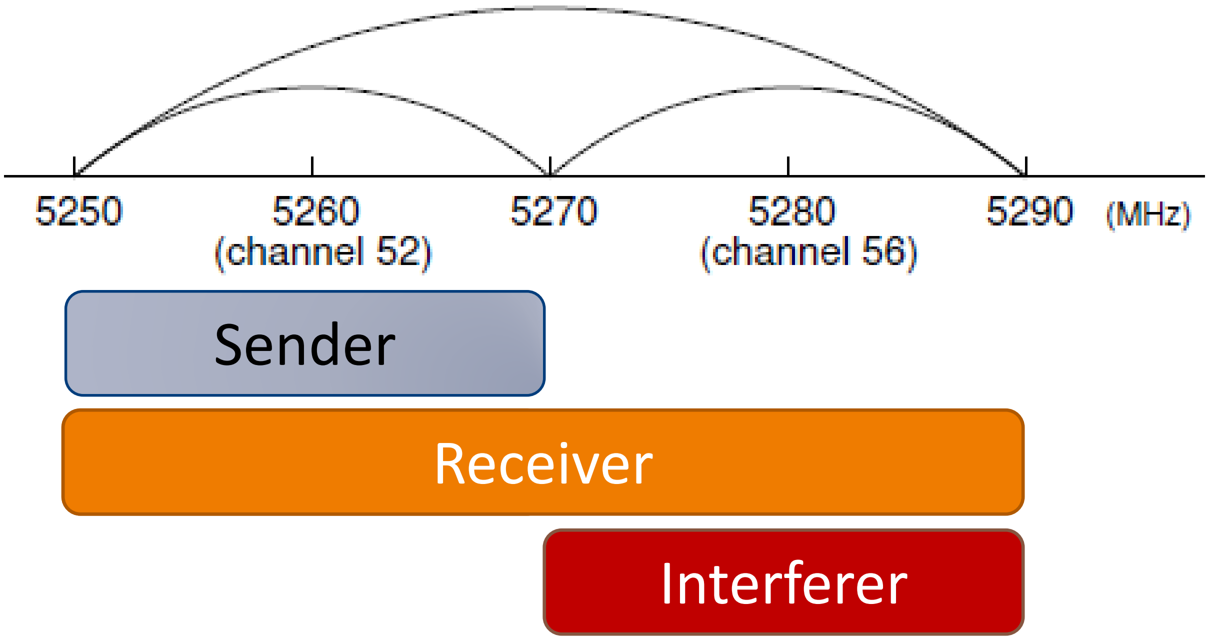
Adjacent Channel Interference



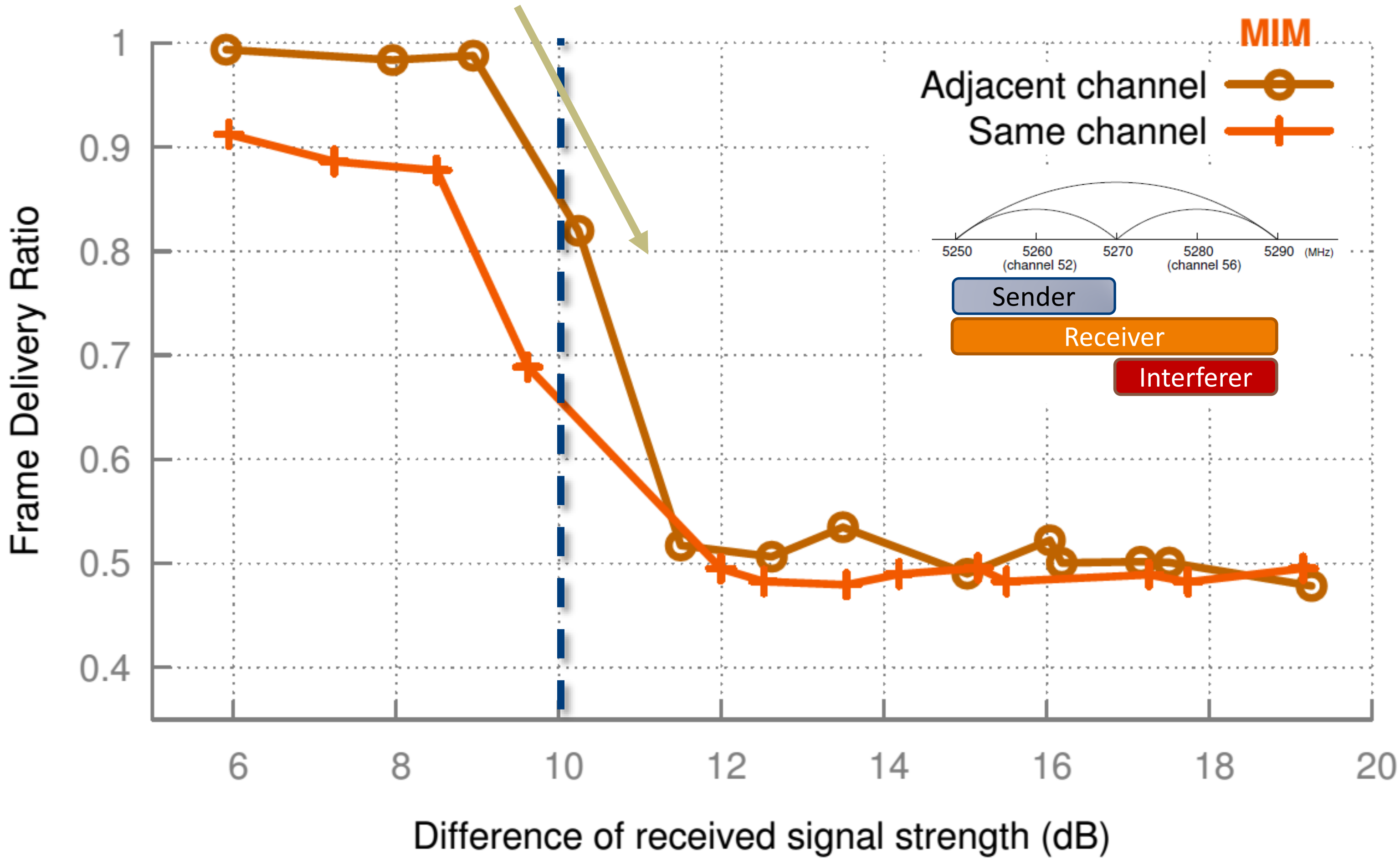
Adjacent Channel Interference



Adjacent Channel Interference



Adjacent Channel Interference

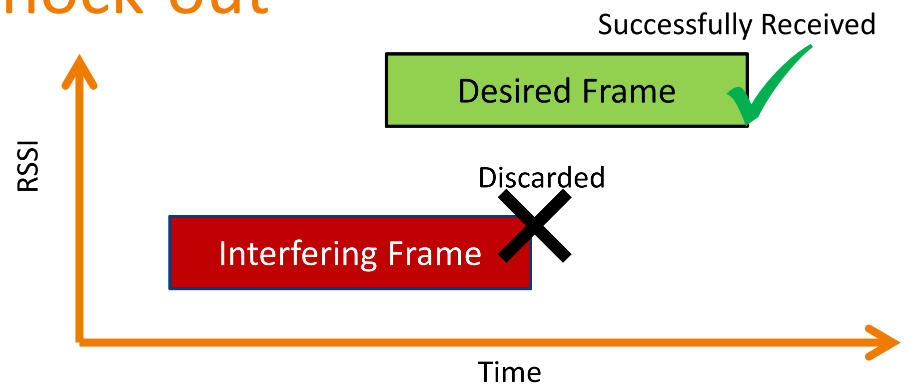


Adaptive MiM

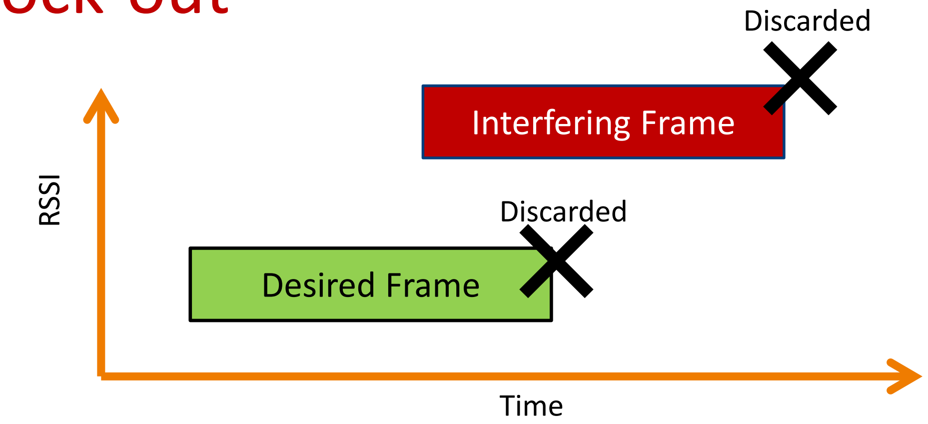
DECIDING WHEN TO ENABLE/DISABLE MIM

Some Definitions

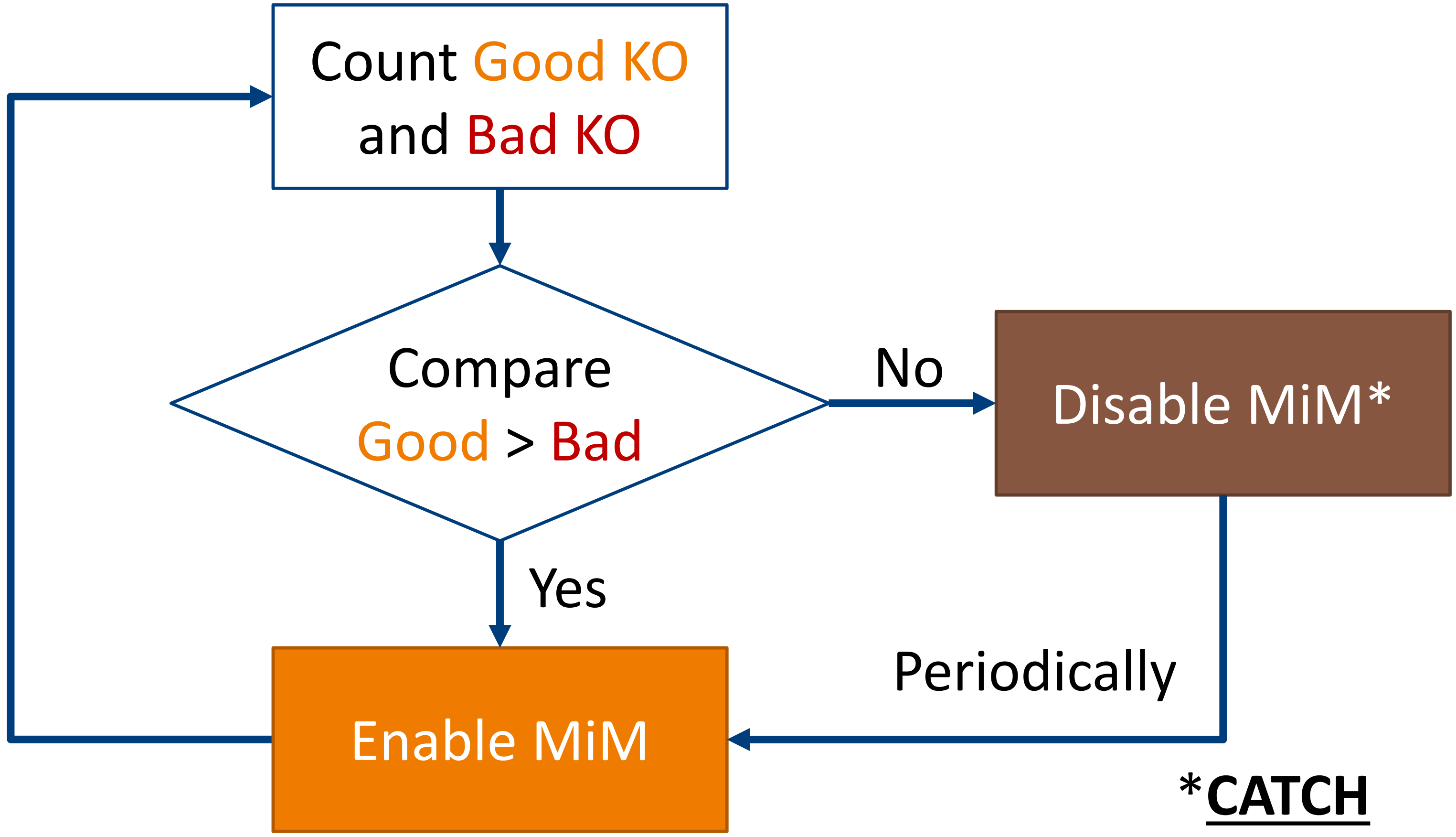
Good Knock-out



Bad Knock-out



Key Idea

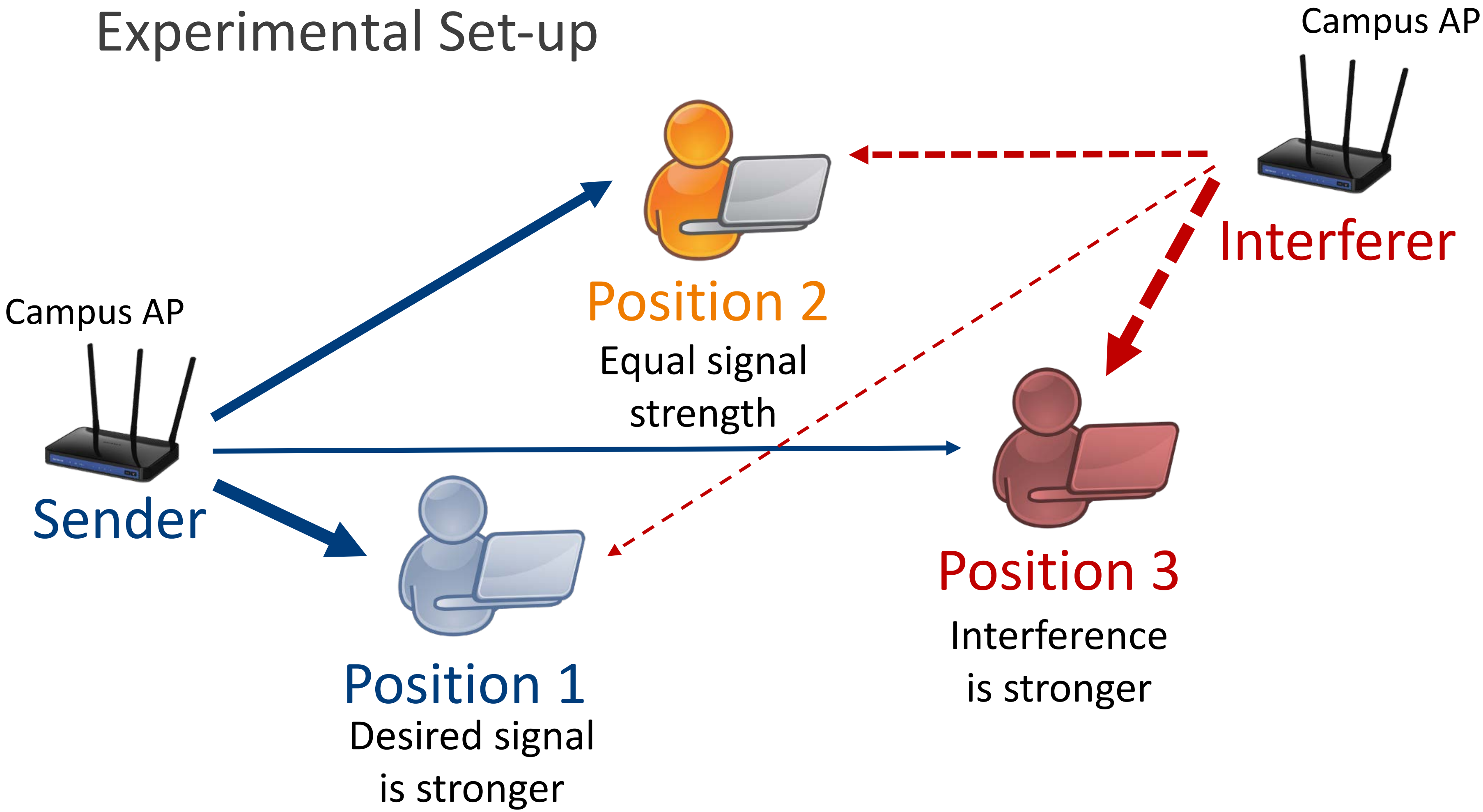


CATCH

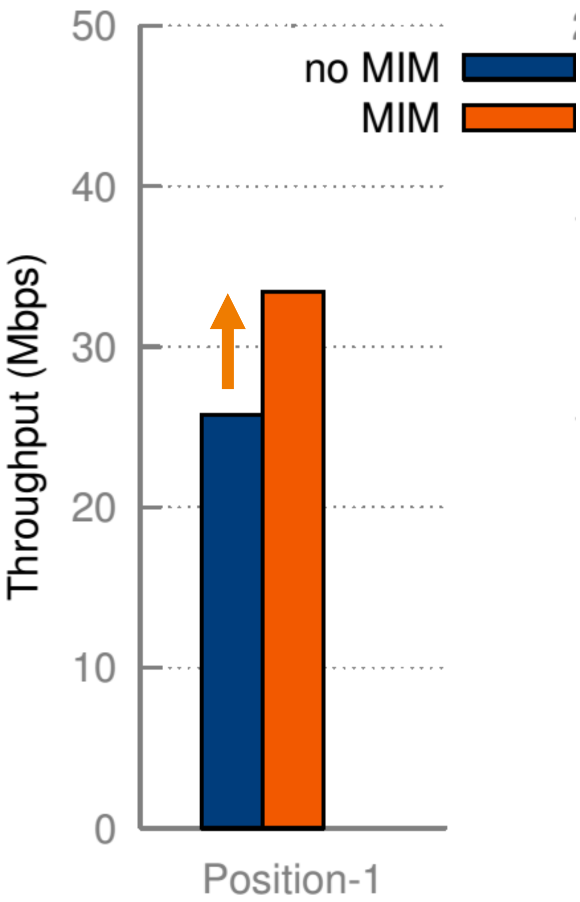
Cannot count with MiM disabled

Evaluation

Experimental Set-up



Results w/o Adaptive MiM

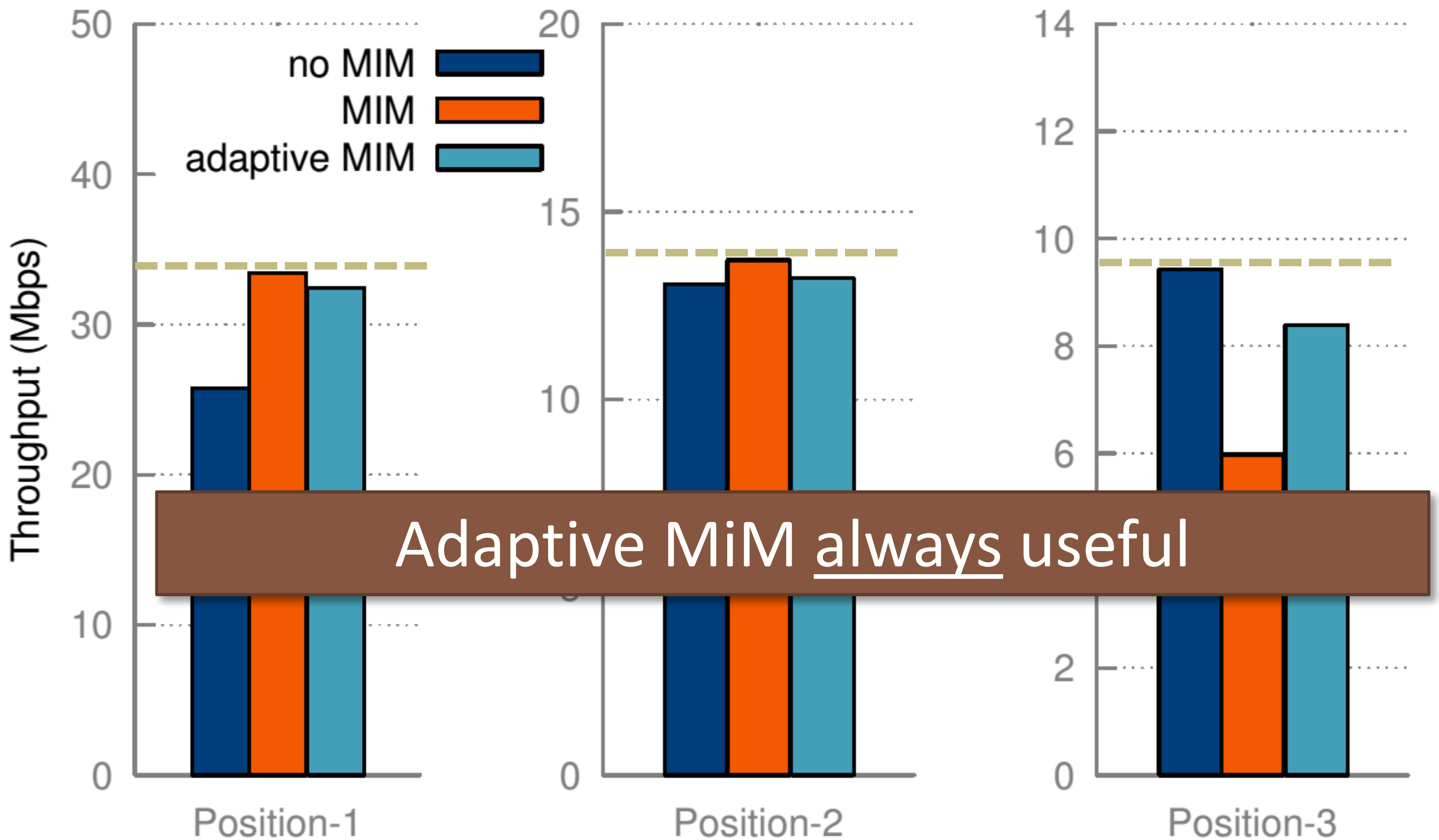


Sender > Interferer
MiM helpful

Sender = Interferer
MiM neutral

Sender < Interferer
MiM detrimental

Results with Adaptive MiM



Adaptive MiM <u>always</u> useful

Sender > Interferer	Sender = Interferer	Sender < Interferer
MiM helpful	MiM neutral	MiM detrimental

In Conclusion

MiM not always helpful, can be harmful

1. Studied harmful effect of MiM
   - on A-MPDUs
   - 10 dB threshold
   - Adjacent Channels

2. Adaptive MiM Algorithm
   - Use MiM only when good
   - Near optimal results

Future Work

1. Update the 802.11 MAC/PHY implementation in simulators like ns-3
2. Analytically model the effect of MiM on A-MPDU
3. Develop algorithm to dynamically adjust A-MPDU size

Thank You

QUESTIONS?

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