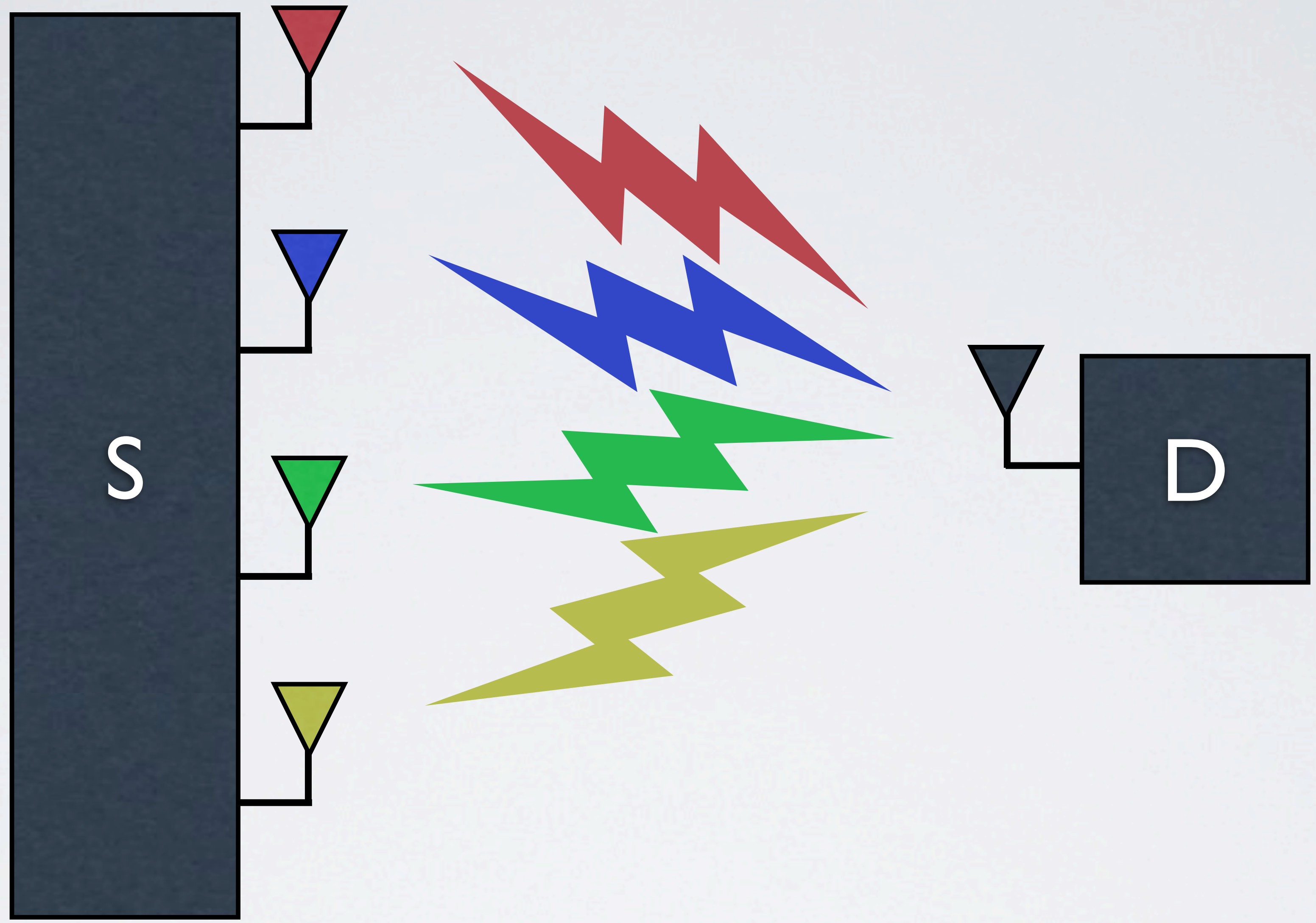
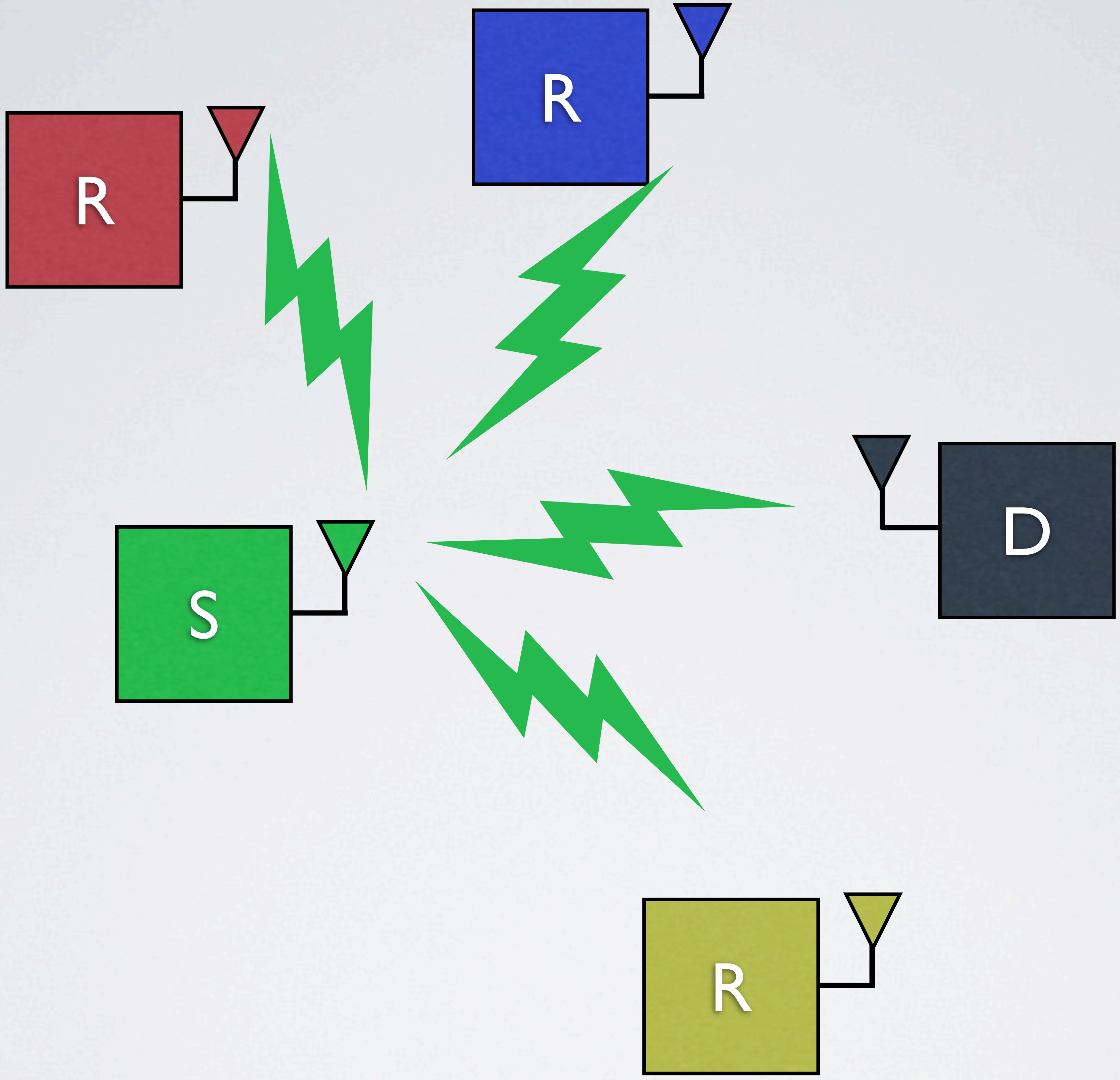
ADVANCED MAC/PHY DESIGN: A COOPERATION CASE STUDY

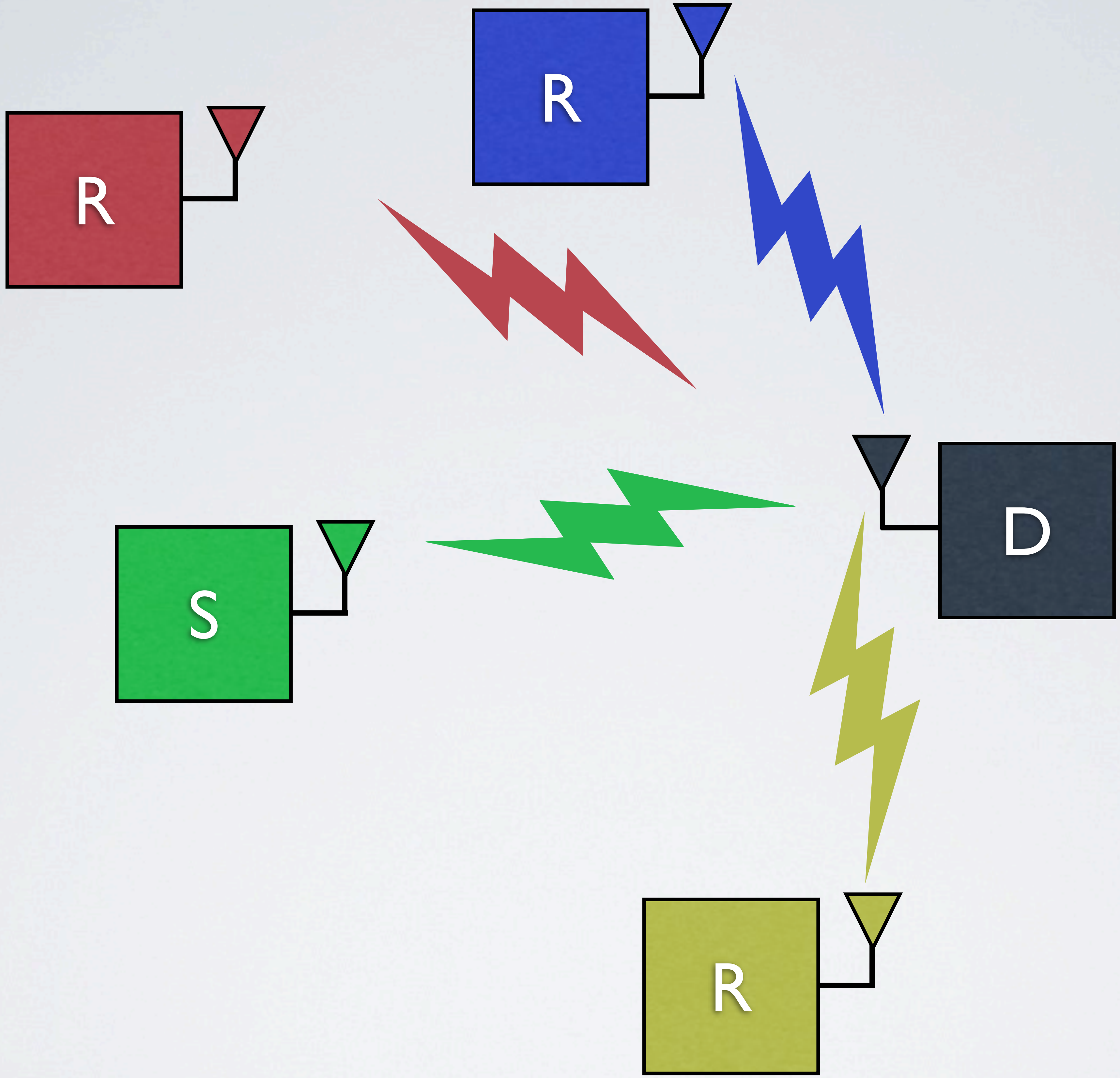
Chris Hunter, Patrick Murphy, Ashu Sabharwal
WARP Workshop 2010

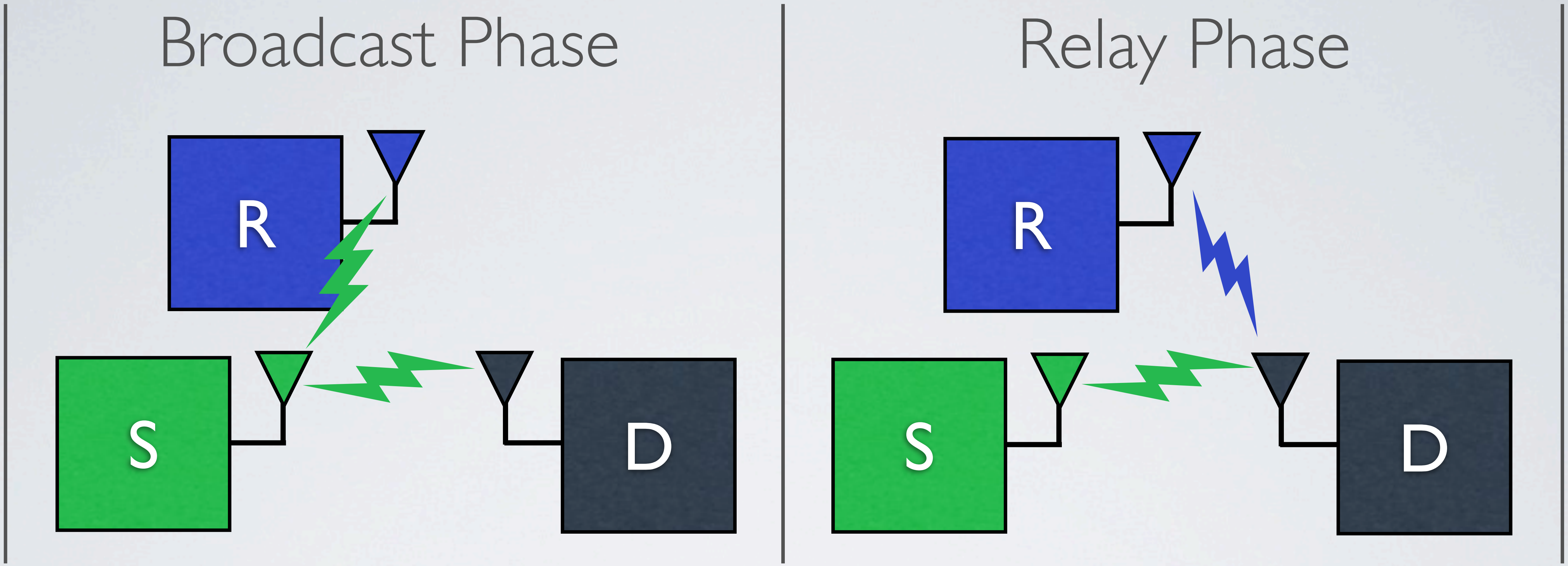
(work available in CISS 2010 proceedings)



- MIMO boosts speed/reliability
- Requires an antenna array
  - Impractical for some applications (e.g. cellphones)


R
R
D
S
R


R
R
S
D
R



- Pitfalls:
  - In high-SNR situations, "Relay Phase" is pure overhead
  - How do you synchronize source and relay?

- Pitfalls:
  - In high-SNR situations, "Relay Phase" is pure overhead
  - How do you synchronize source and relay?

Distributed **O**n-demand **C**ooperation (**DOC**)

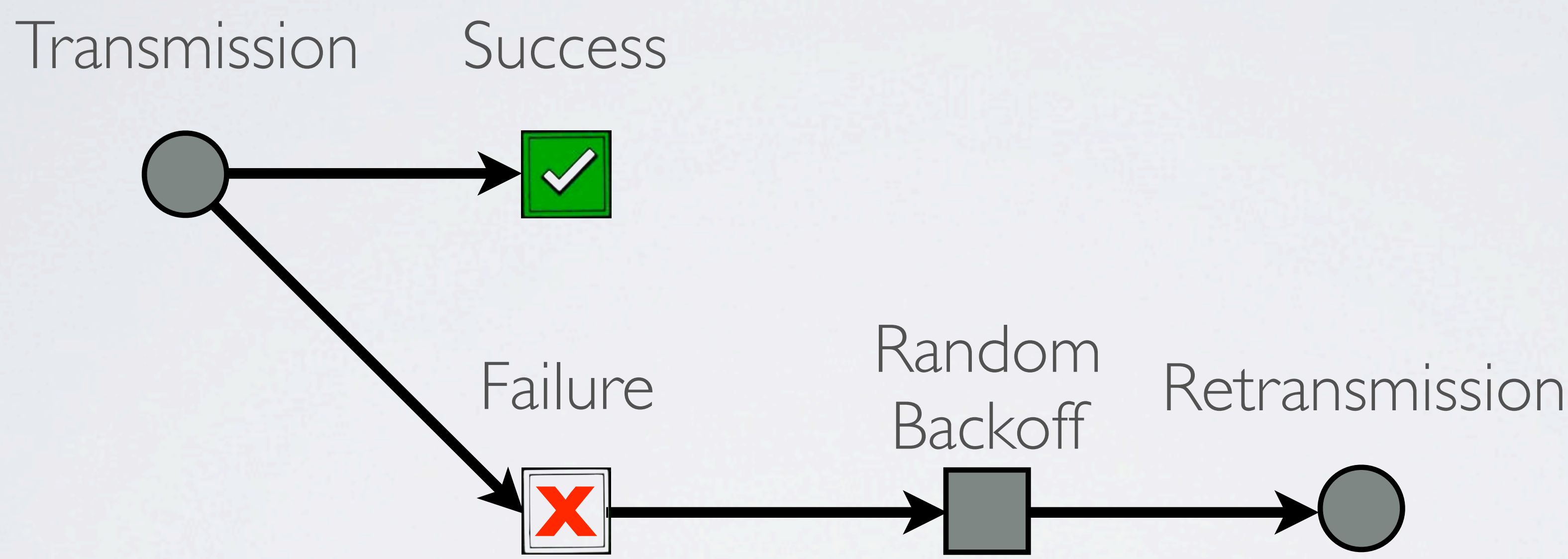
- Completely severed from centralized scheduling
- Only cooperates when it can help
- Emphasis on practicality; we've built it

DOC | OUTLINE

- MAC Details
- PHY Details
- Implementation Details
- Measurement Results

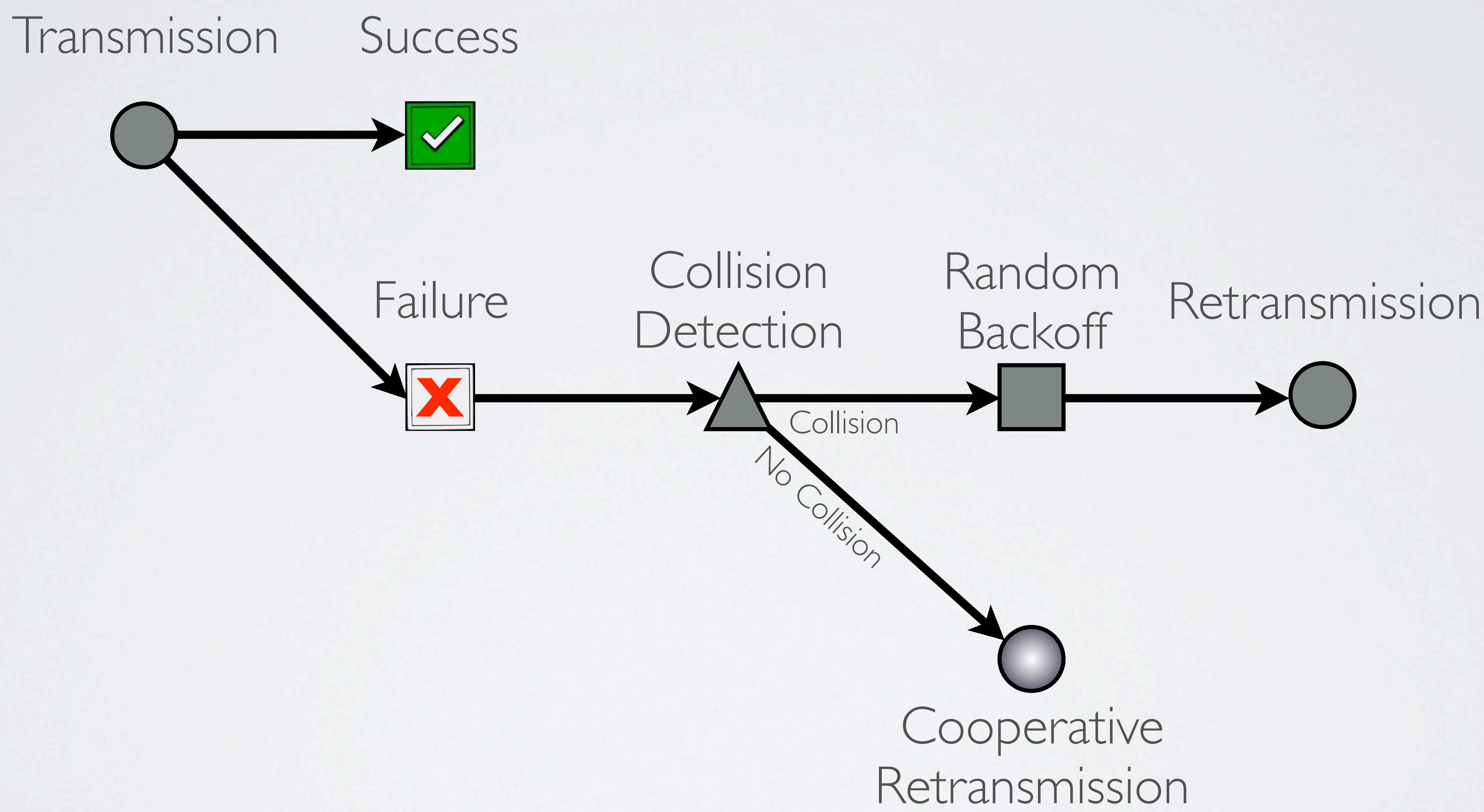
DOC|MAC

DOC|MAC CSMA/CA

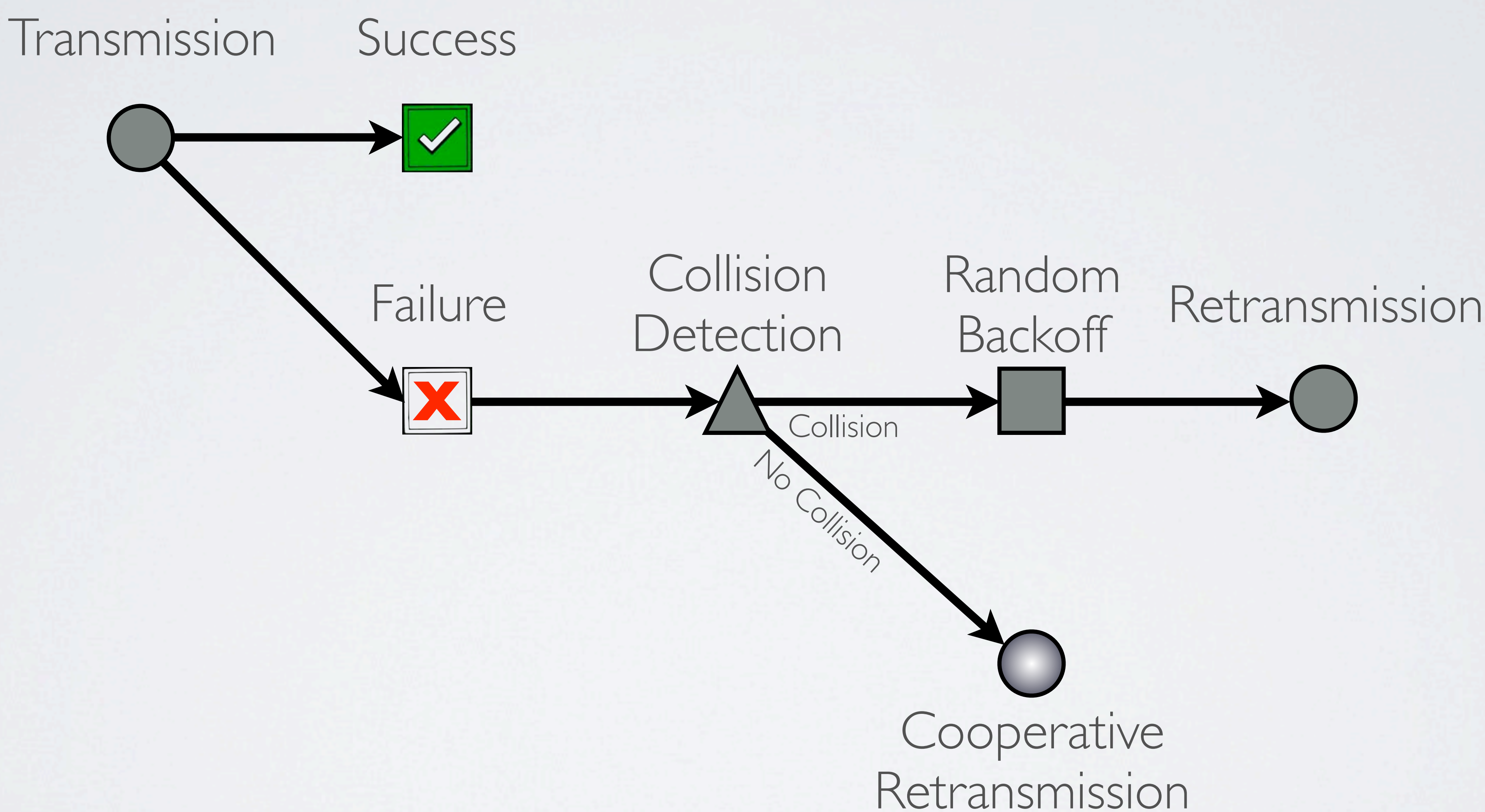


- CSMA/CA assumes **every** packet loss is due to a collision

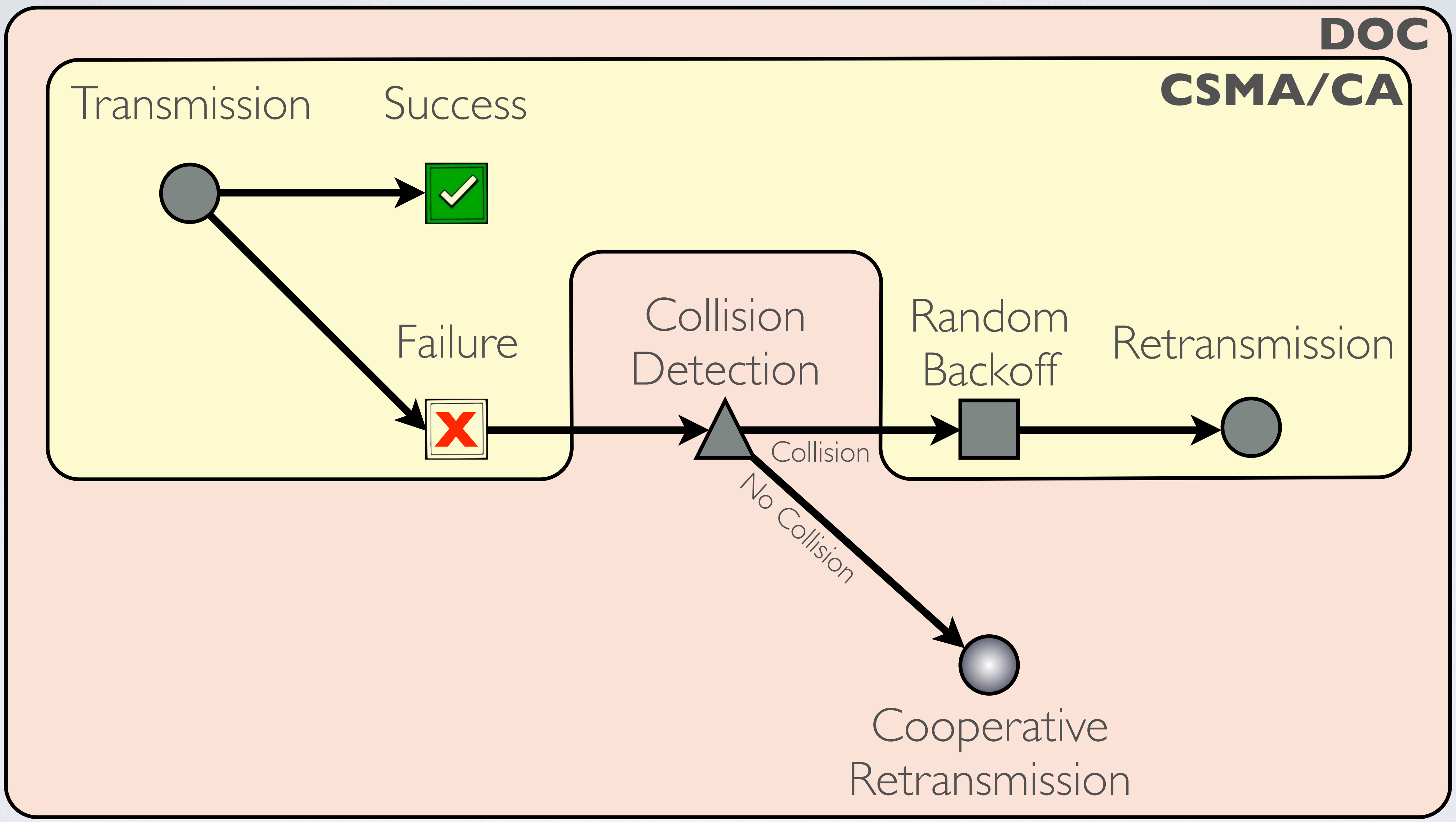
DOC|MAC


Transmission
Success
Failure
Collision
Detection
Random
Backoff
Retransmission
Collision
No Collision
Cooperative
Retransmission

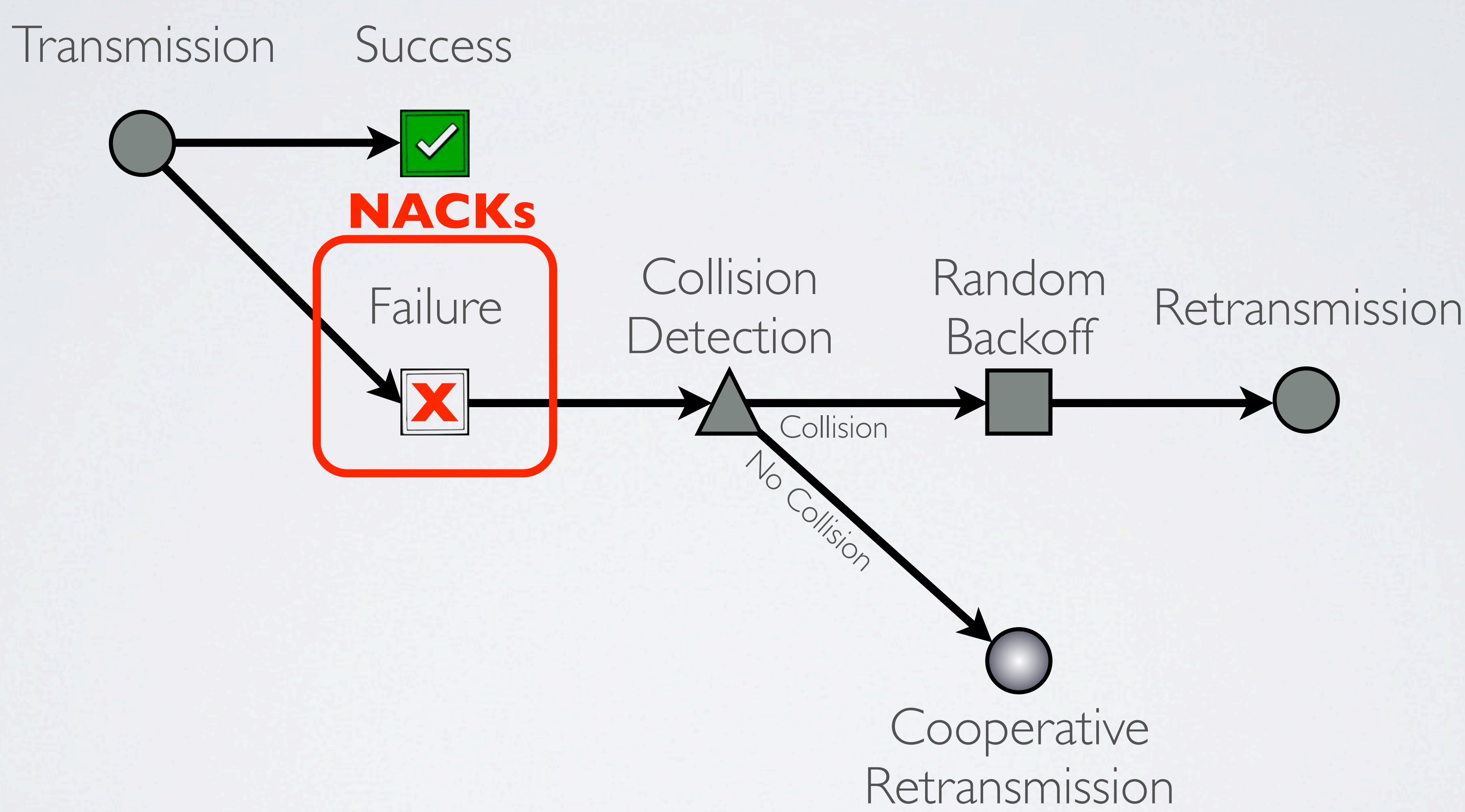
DOC|MAC


Transmission
Success
Failure
Collision
Detection
Random
Backoff
Retransmission
Collision
No Collision
Cooperative
Retransmission

DOC|MAC

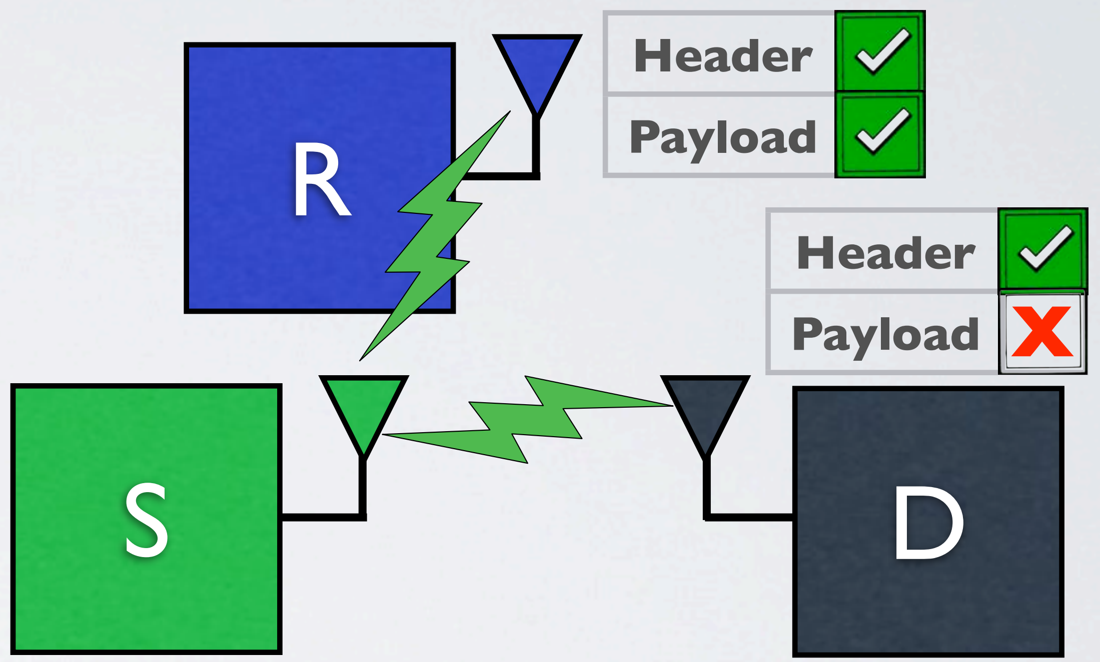

DOC
CSMA/CA
Transmission
Success
Failure
Collision Detection
Random Backoff
Retransmission
Collision
No Collision
Cooperative Retransmission

DOC|MAC

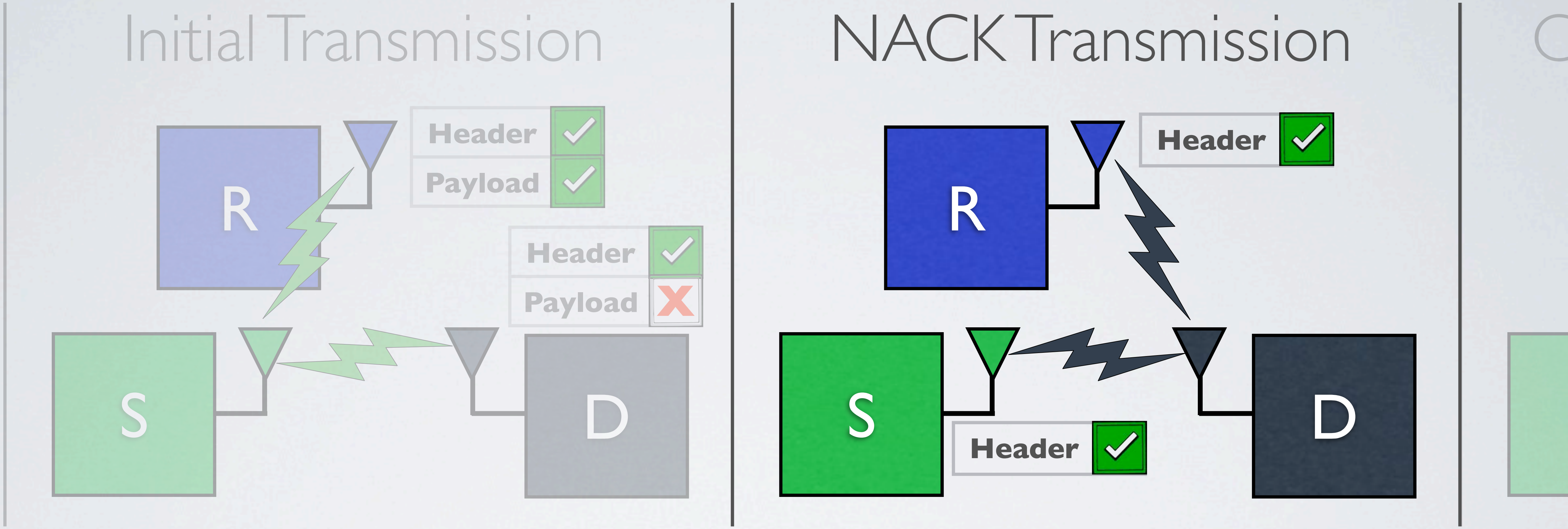

Transmission
Success
NACKs
Failure
Collision Detection
Collision
No Collision
Random Backoff
Retransmission
Cooperative Retransmission

DOC | EXAMPLE

Initial Transmission

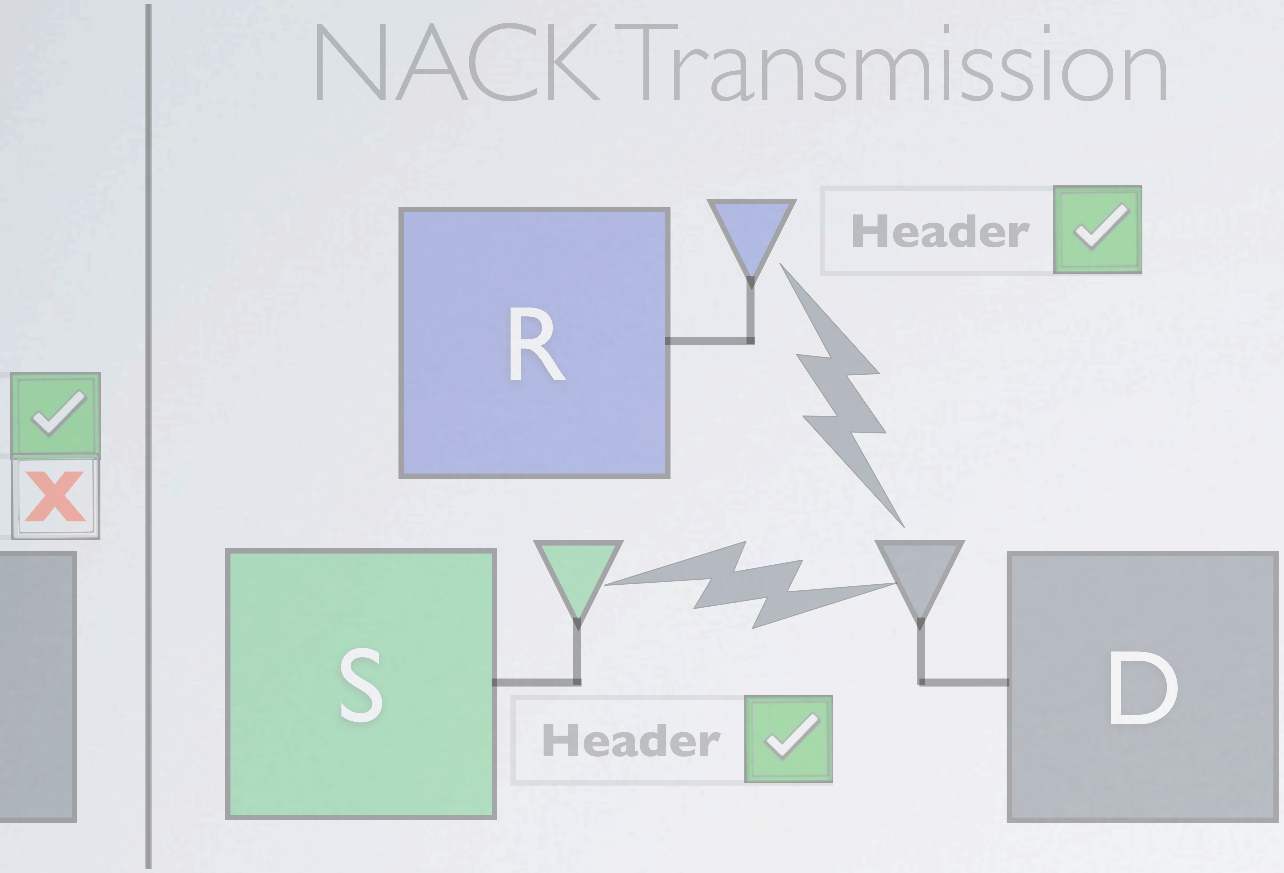


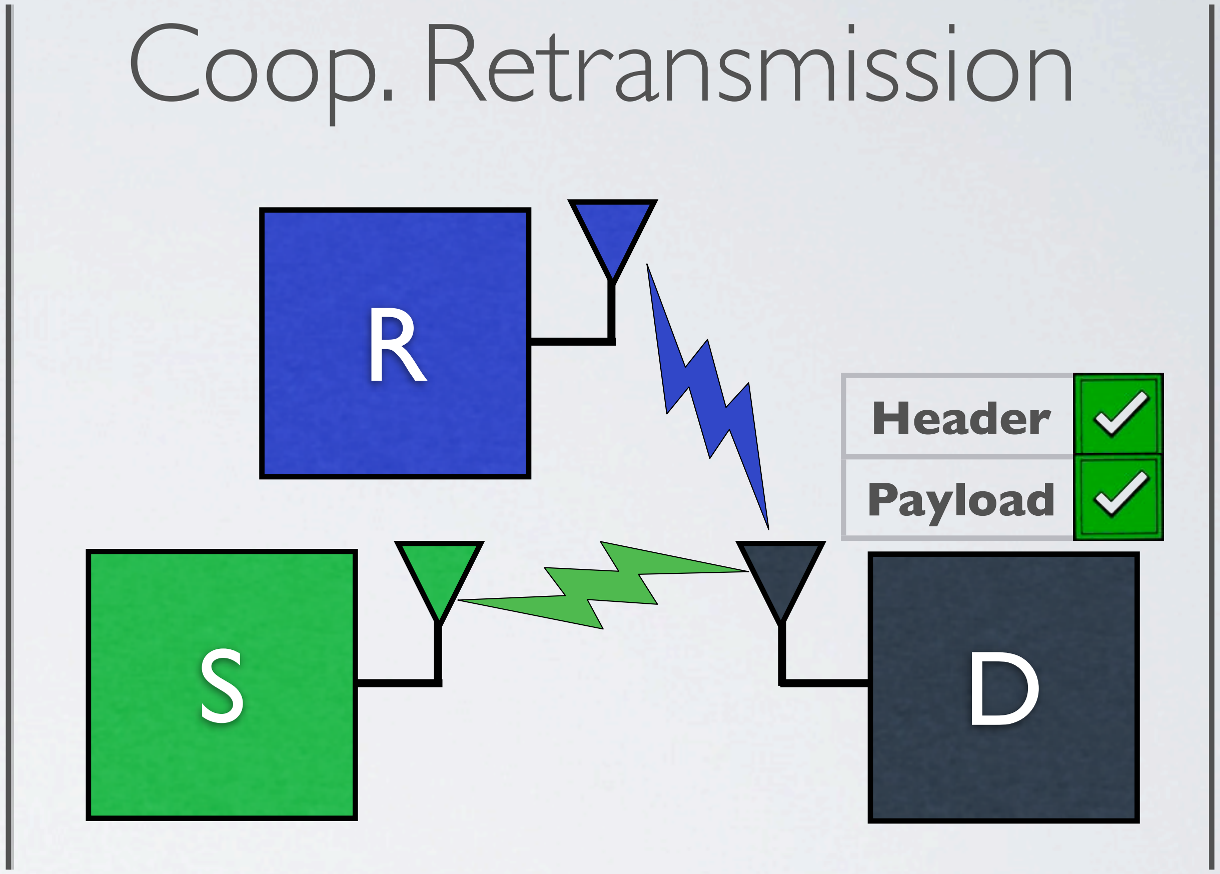
DOC EXAMPLE



Initial Transmission
R
Header
Payload
Header
Payload
S
D
NACK Transmission
R
Header
S
Header
D

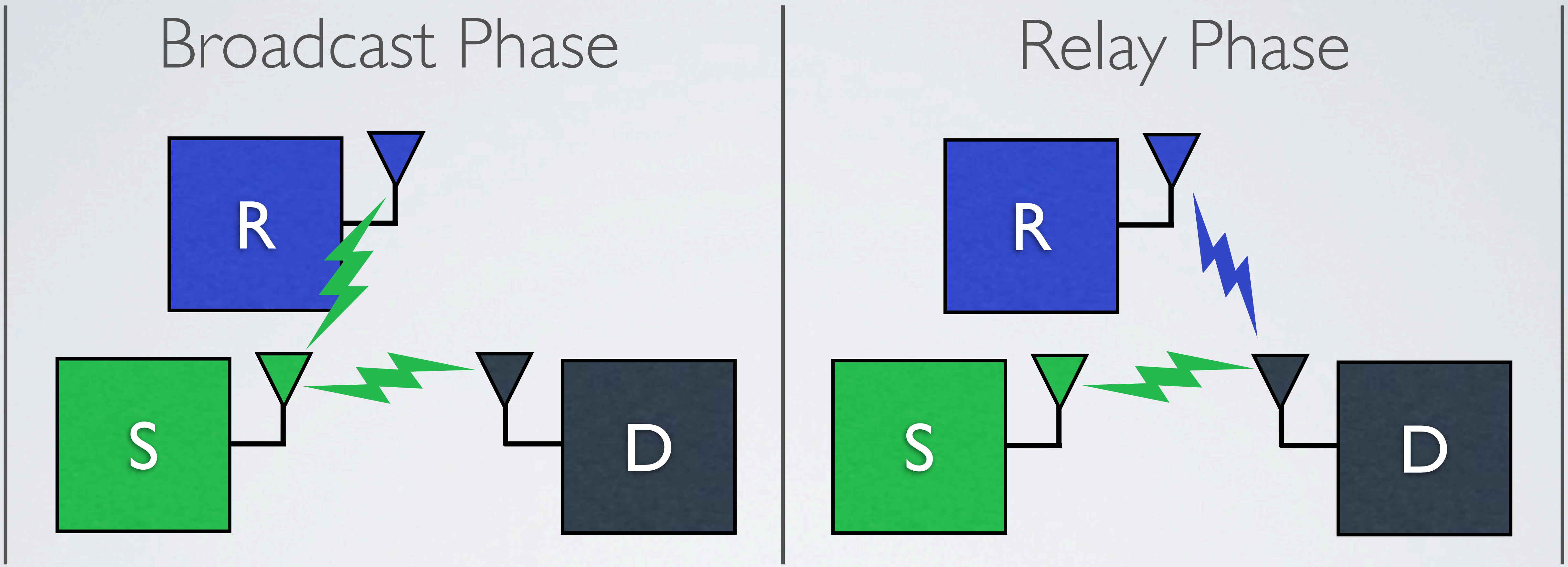
DOC|EXAMPLE


NACK Transmission
R
Header
S
Header
D


Coop. Retransmission
R
Header
Payload
S
D

DOCPHY

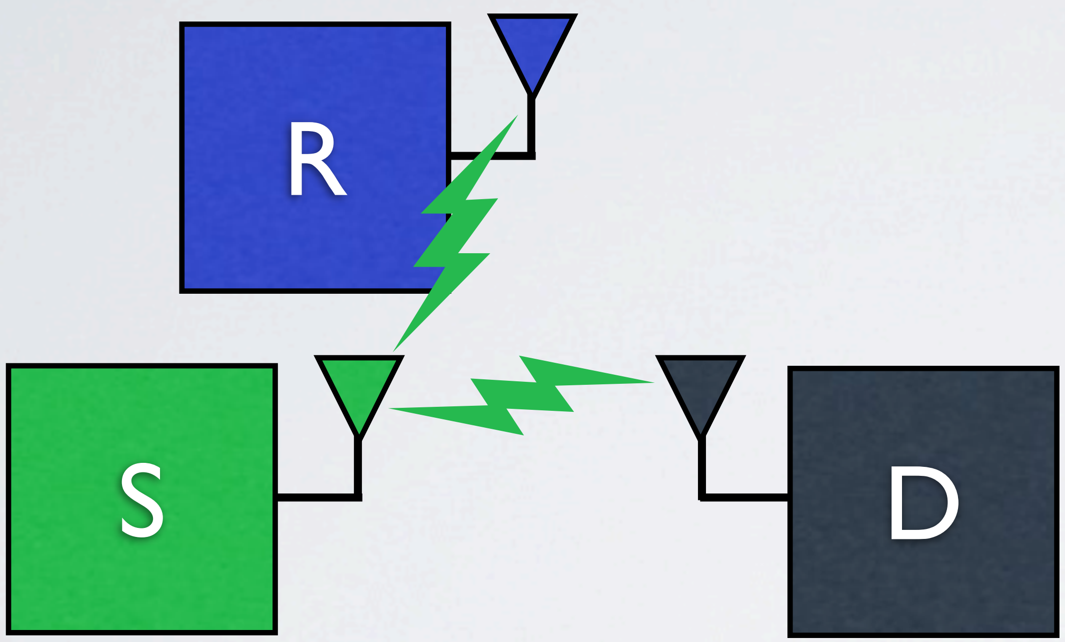
DOC|PHY
Distributed Alamouti STBC



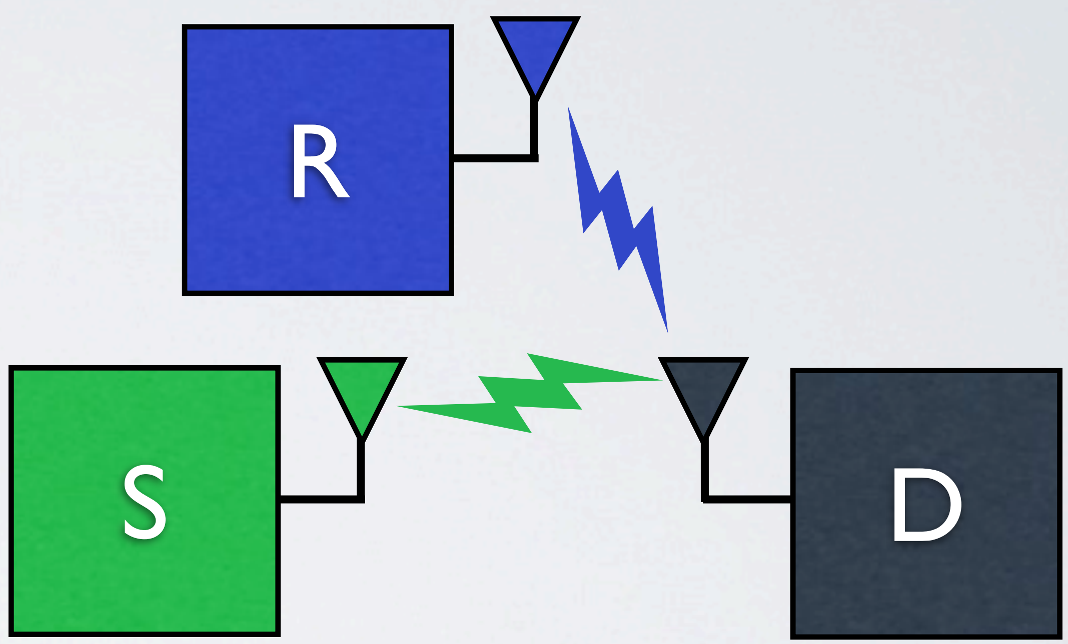
DOC|PHY

Distributed Alamouti STBC

Broadcast Phase



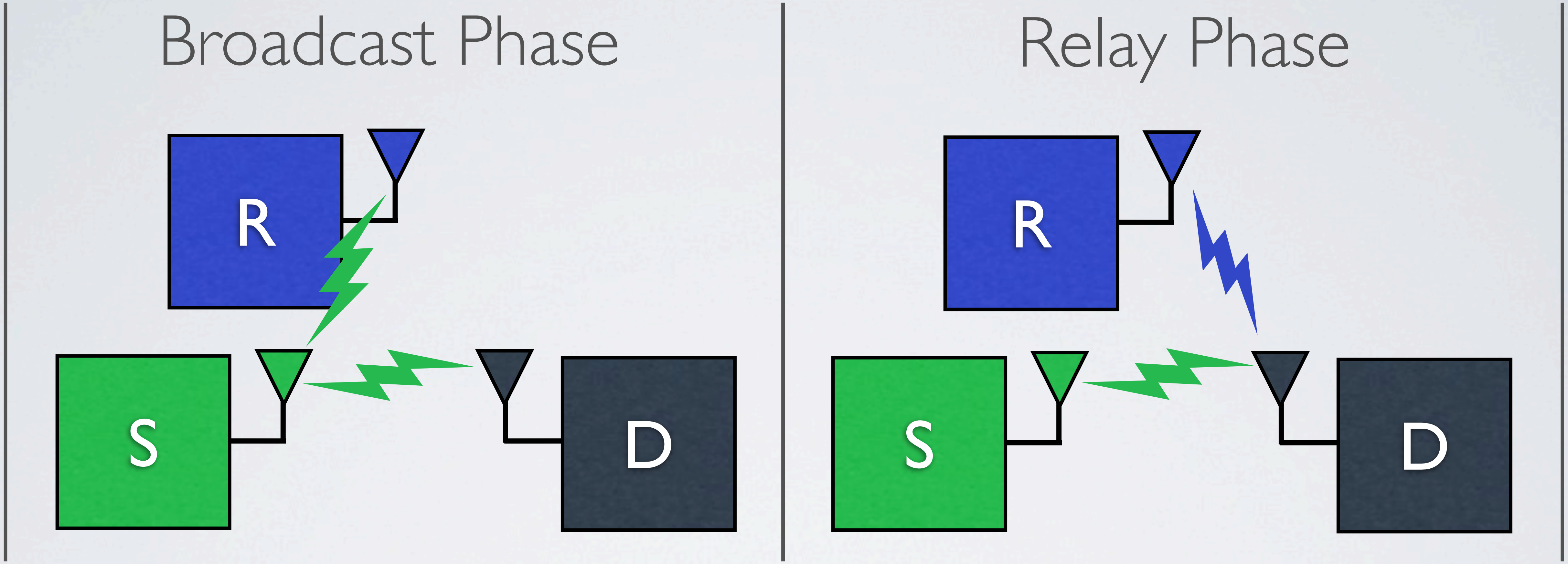
Relay Phase



$$\mathrm{ANT\_A} = [s_0, -s_1^*, s_2, -s_3^*, \ldots]$$

DOC|PHY

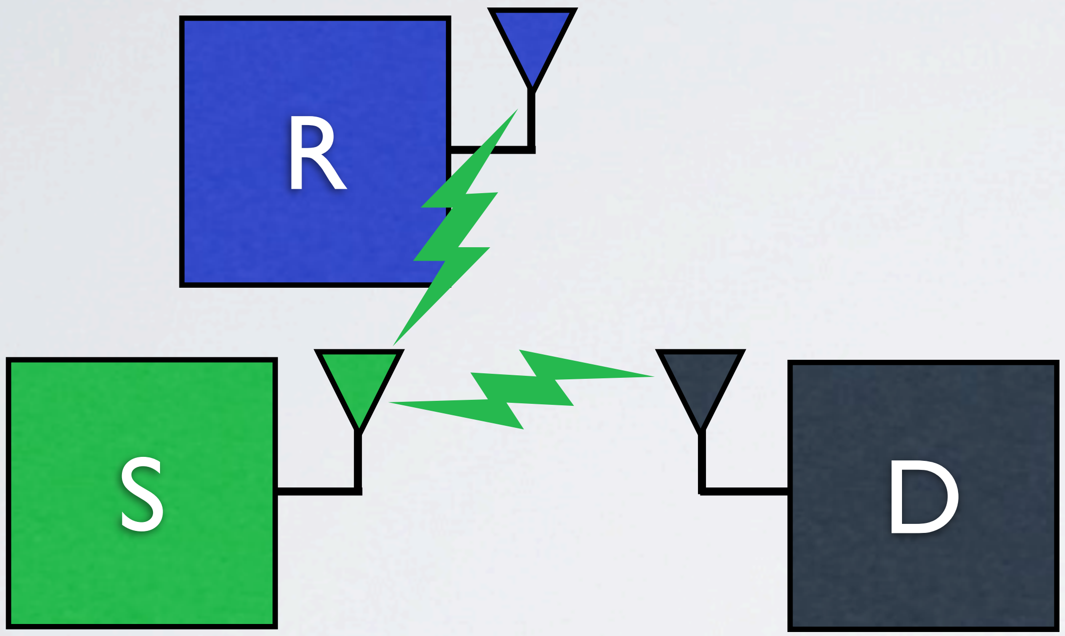
Distributed Alamouti STBC



$\mathrm{ANT\_A} = [s_0, -s_1^*, s_2, -s_3^*, \ldots]$ $\mathrm{ANT\_A} = [s_0, -s_1^*, s_2, -s_3^*, \ldots]$

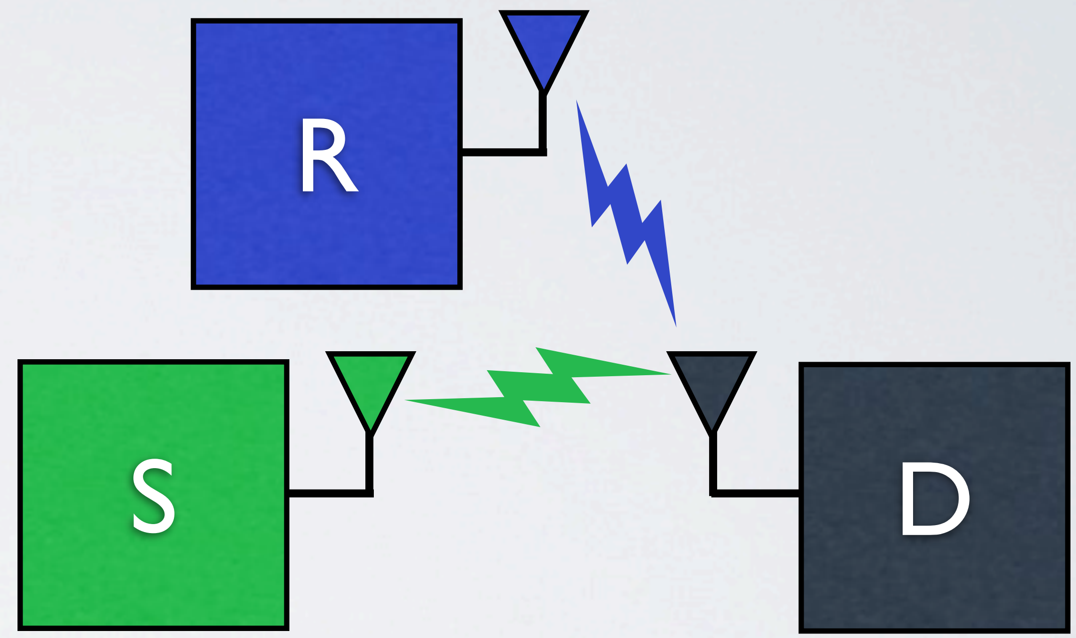
DOC|PHY Distributed Alamouti STBC

Broadcast Phase



$$\text{ANT\_A} = [s_0, -s_1^*, s_2, -s_3^*, \ldots]$$

Relay Phase

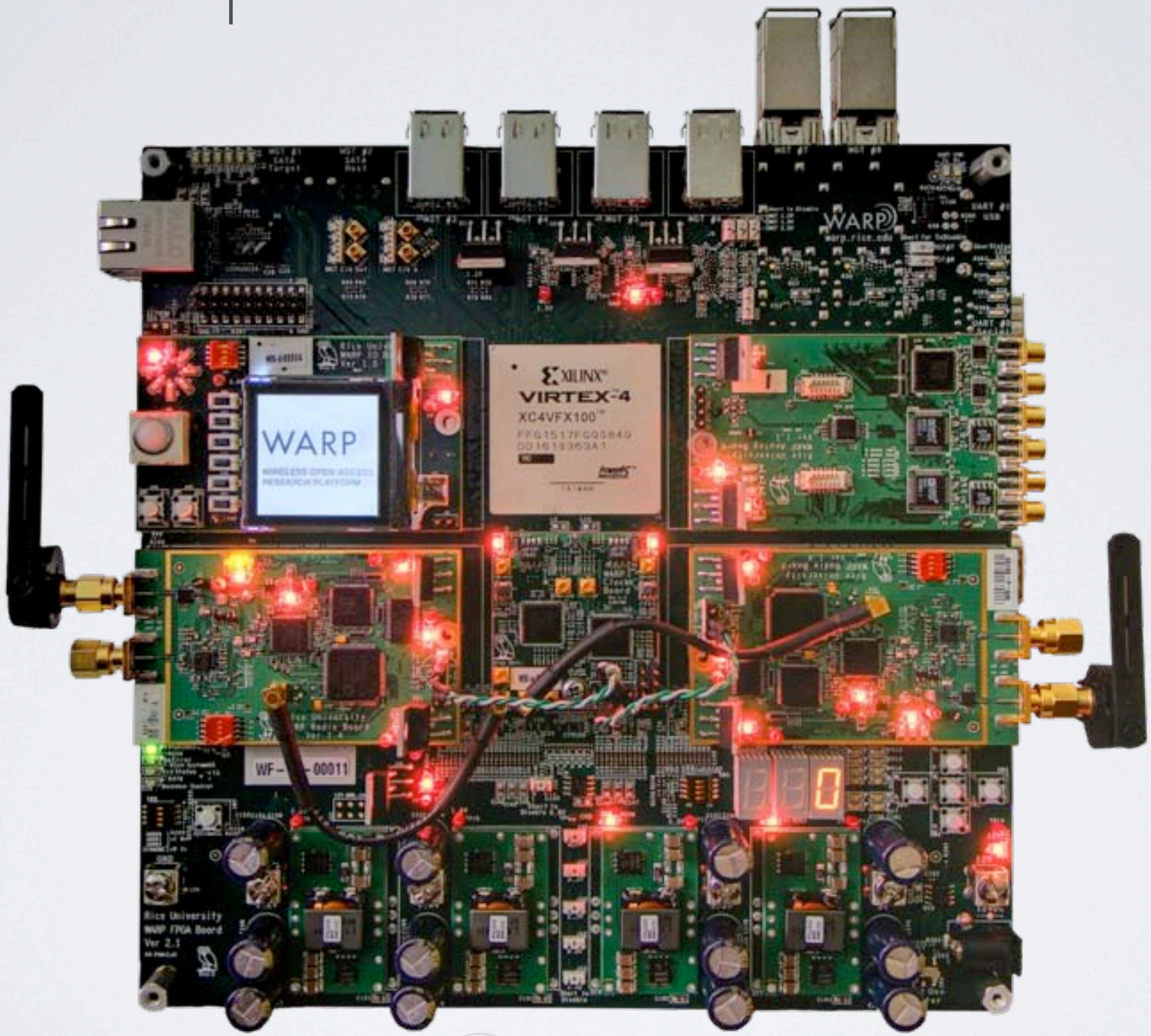


$$\text{ANT\_A} = [s_0, -s_1^*, s_2, -s_3^*, \ldots]$$

$$\text{ANT\_B} = [s_1, s_0^*, s_3, s_2^*, \ldots]$$

DOC | IMPLEMENTATION

DOC | IMPLEMENTATION

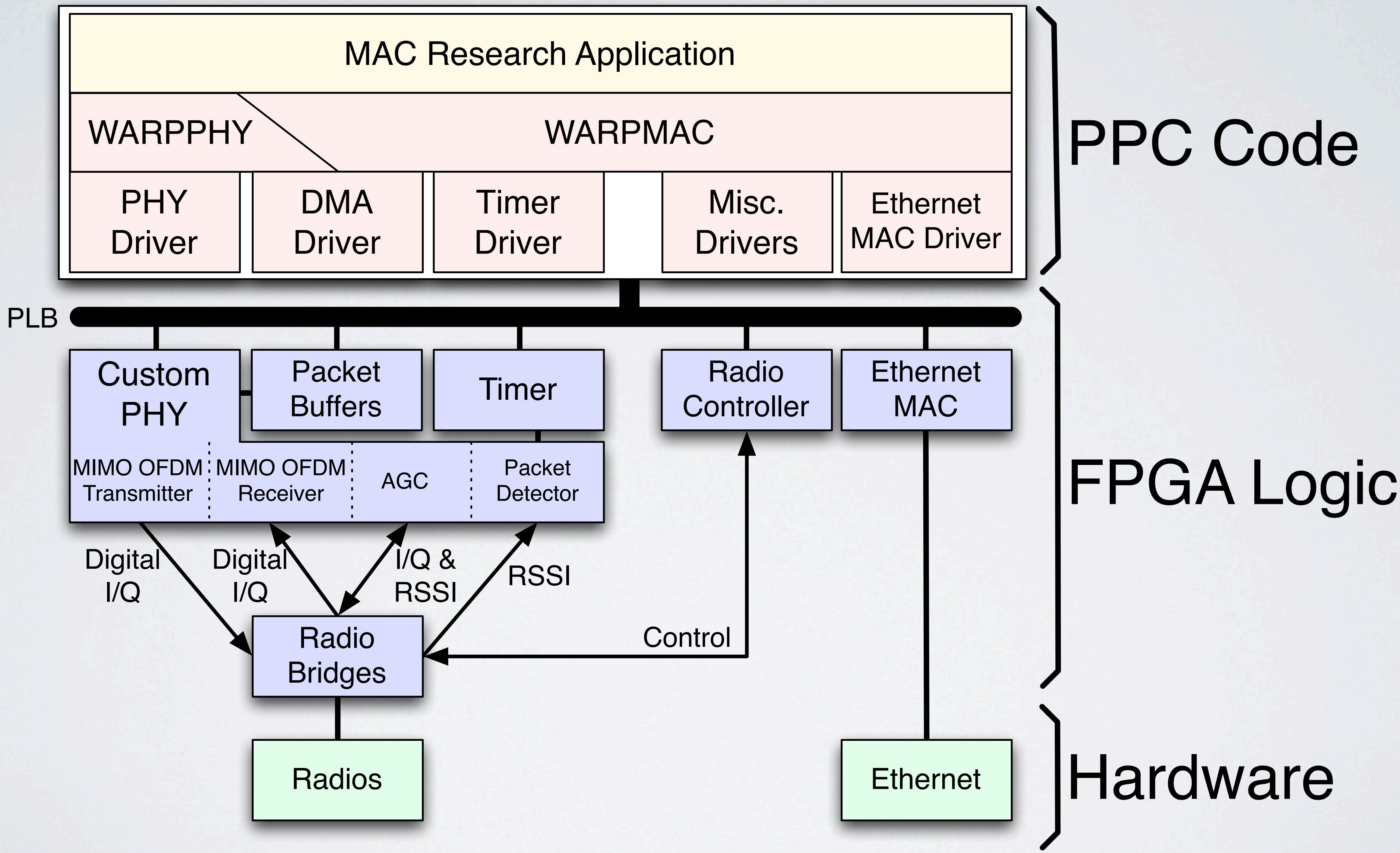


WARP WIRELESS OPEN-ACCESS RESEARCH PLATFORM

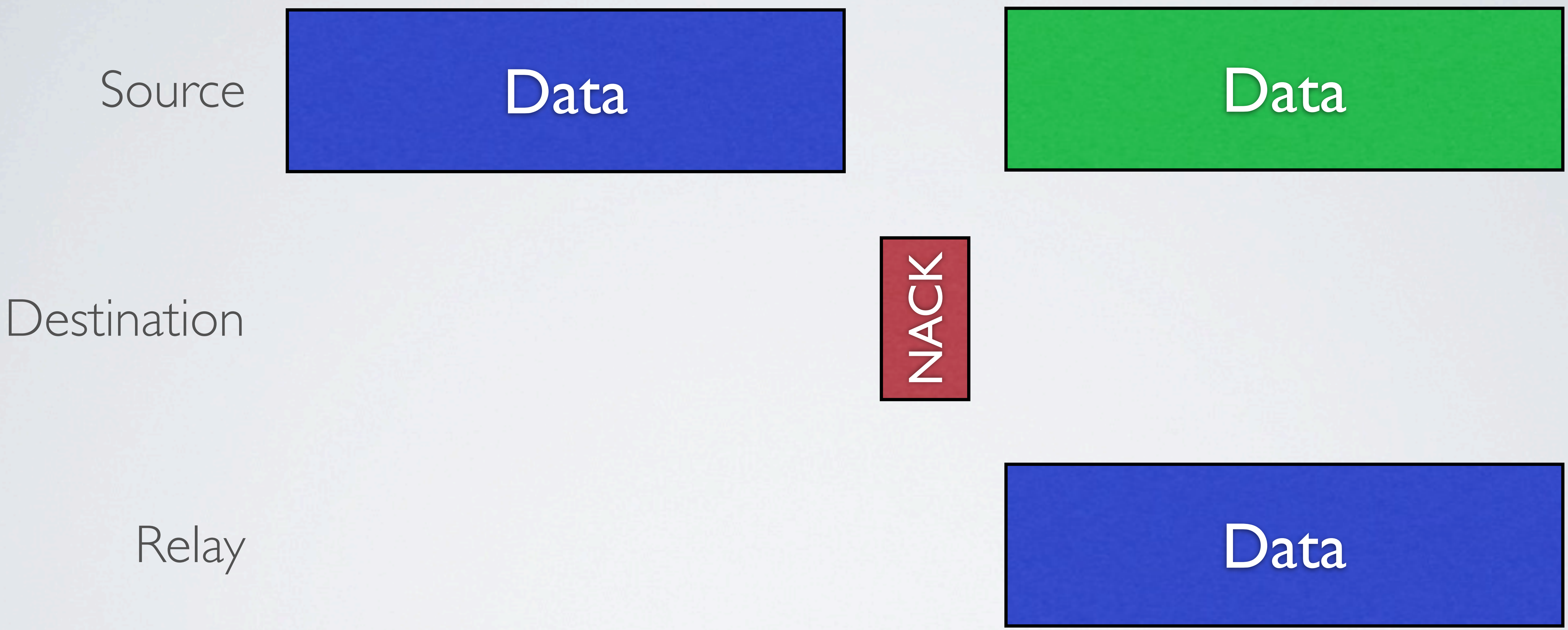
DOC | IMPLEMENTATION

DOC | IMPLEMENTATION

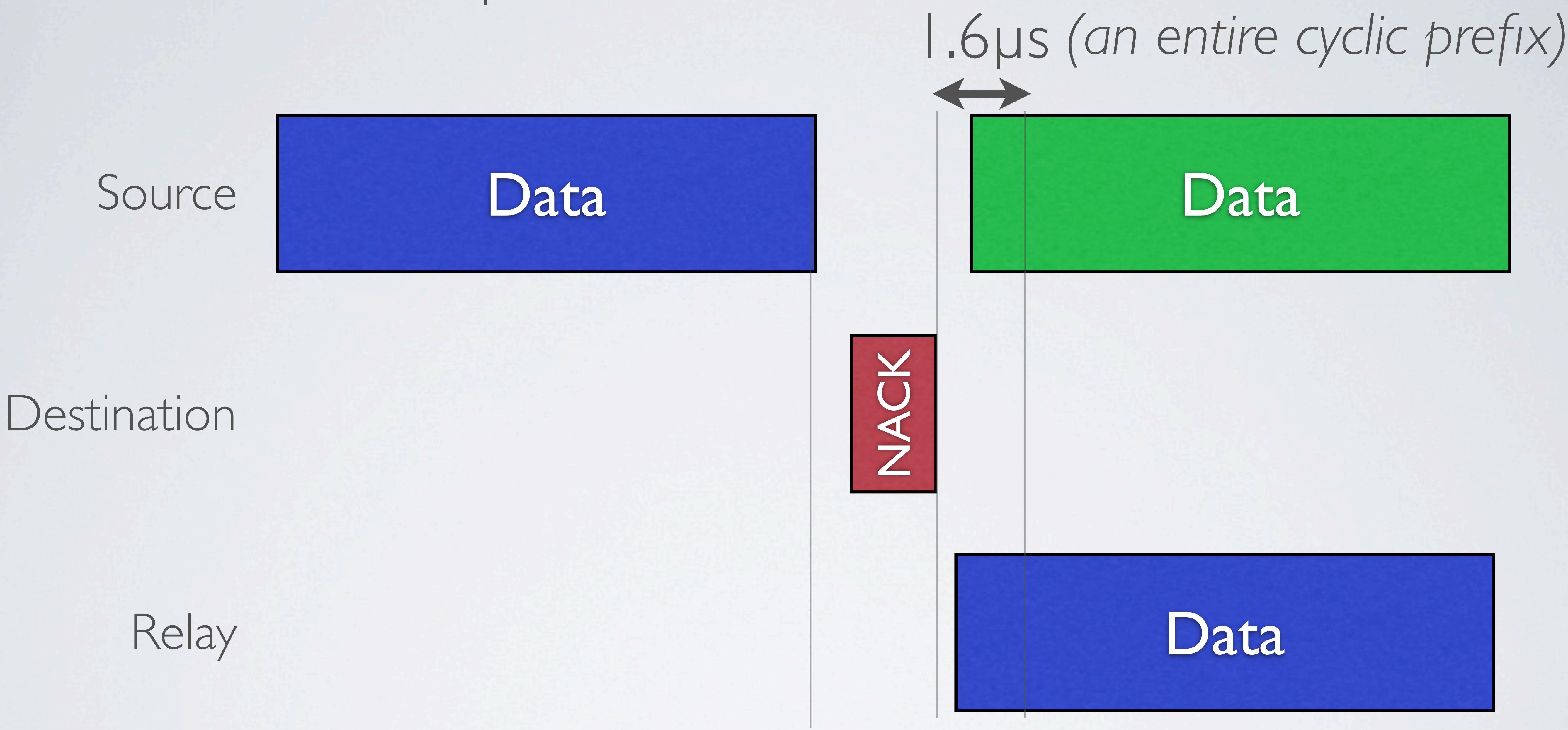
MIMO Reference Design



DOC | IMPLEMENTATION



DOC|IMPLEMENTATION

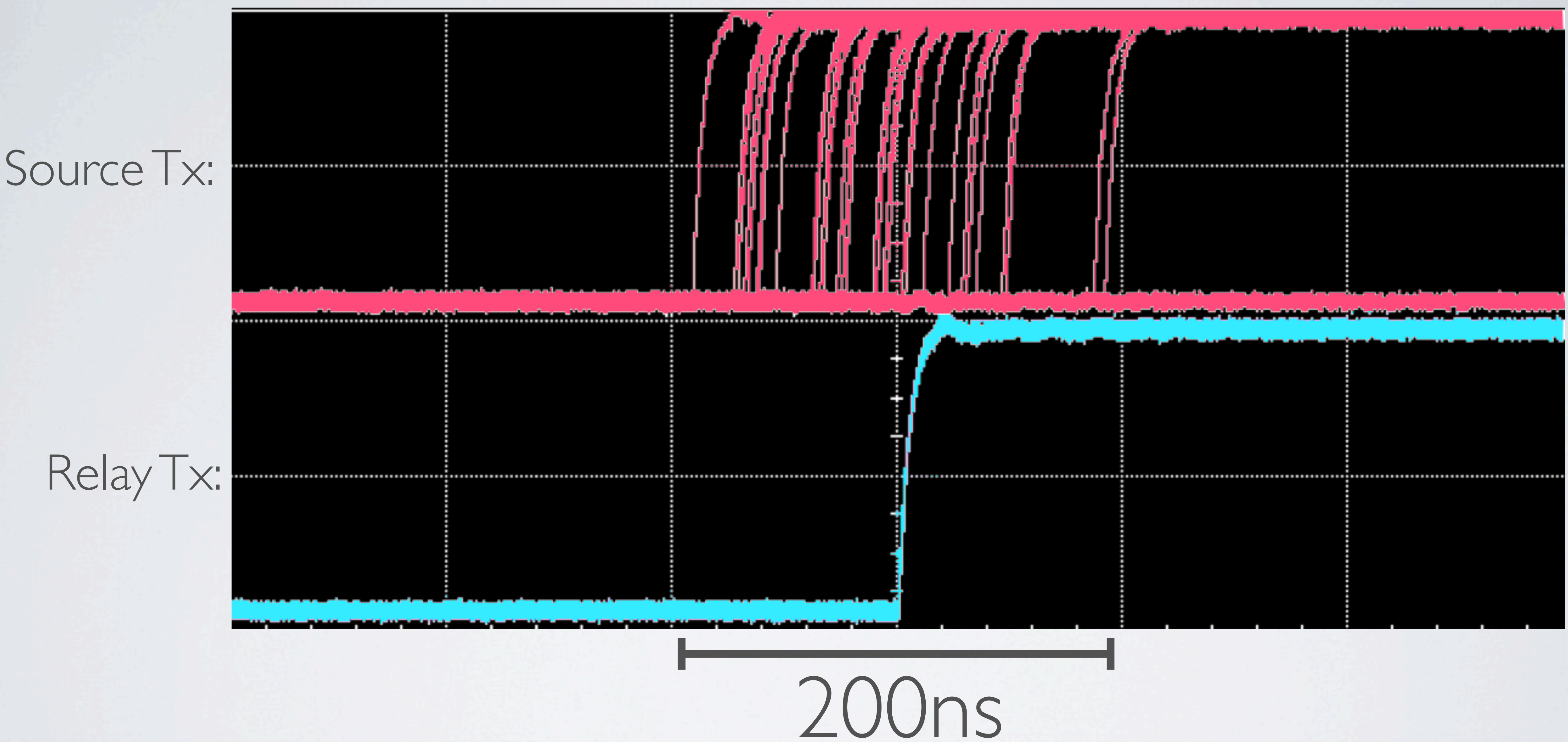


Solution: Harden packet responses to fabric

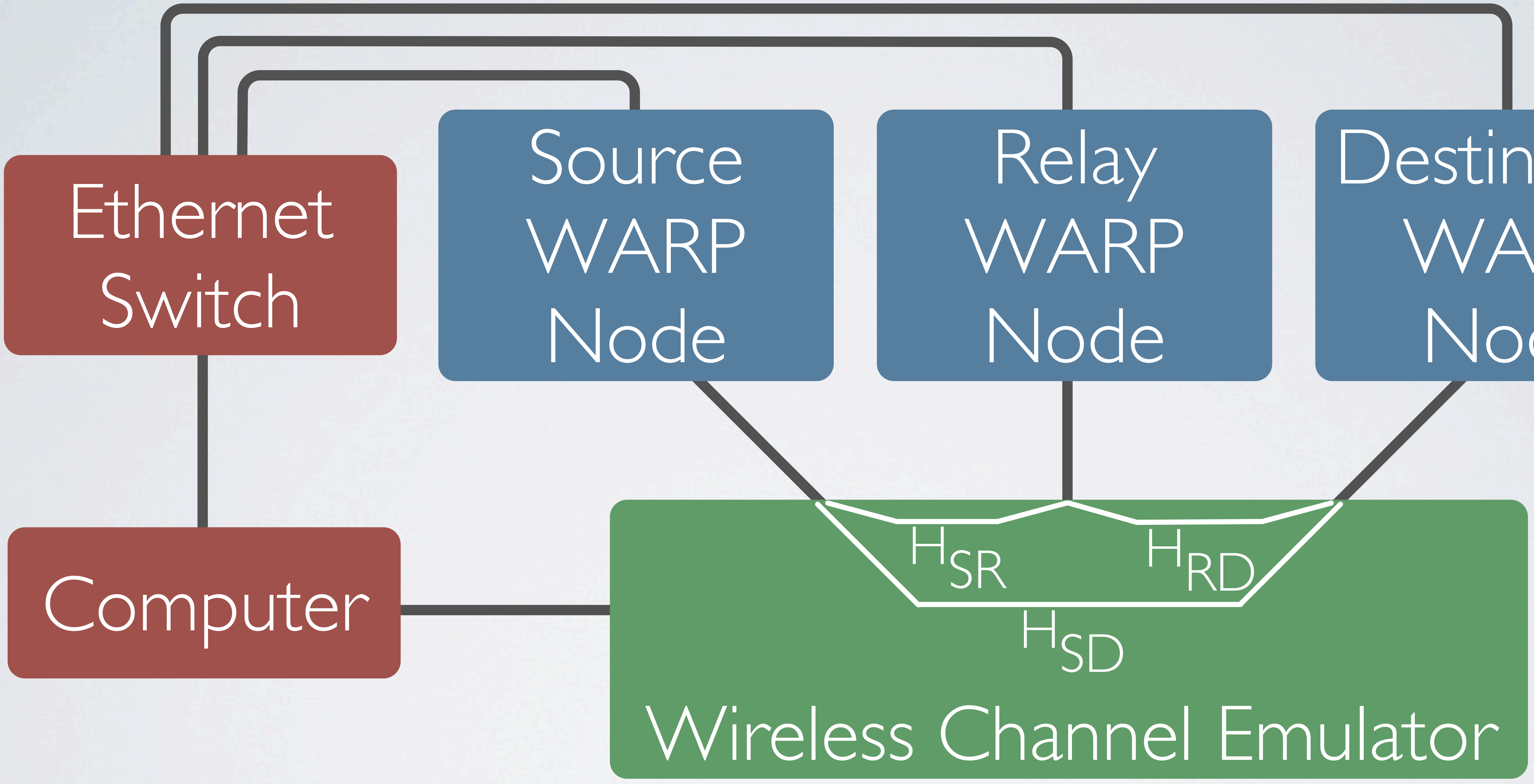
DOC|IMPLEMENTATION

Autoresponder

DOC | IMPLEMENTATION
Autoresponder

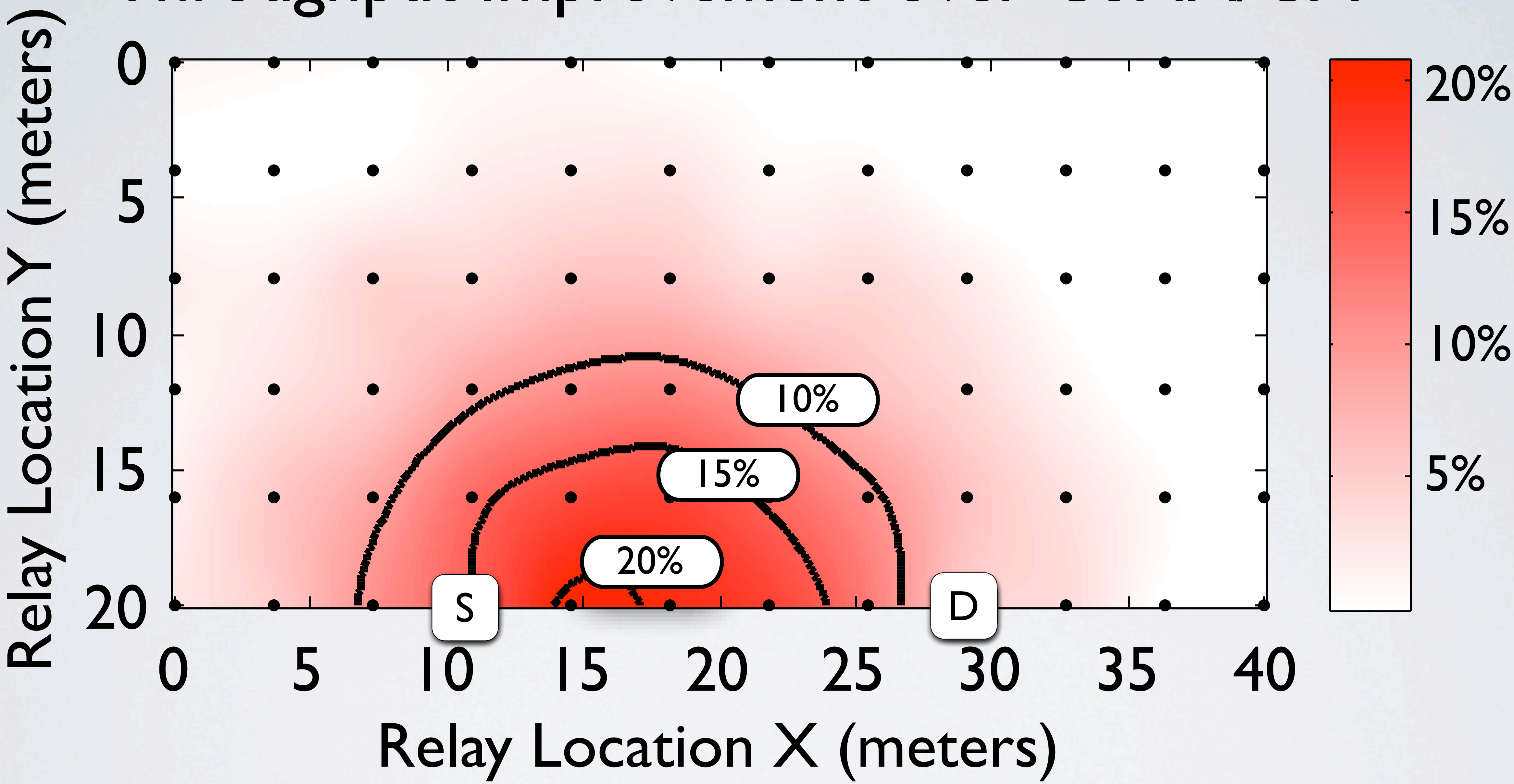


DOC RESULTS

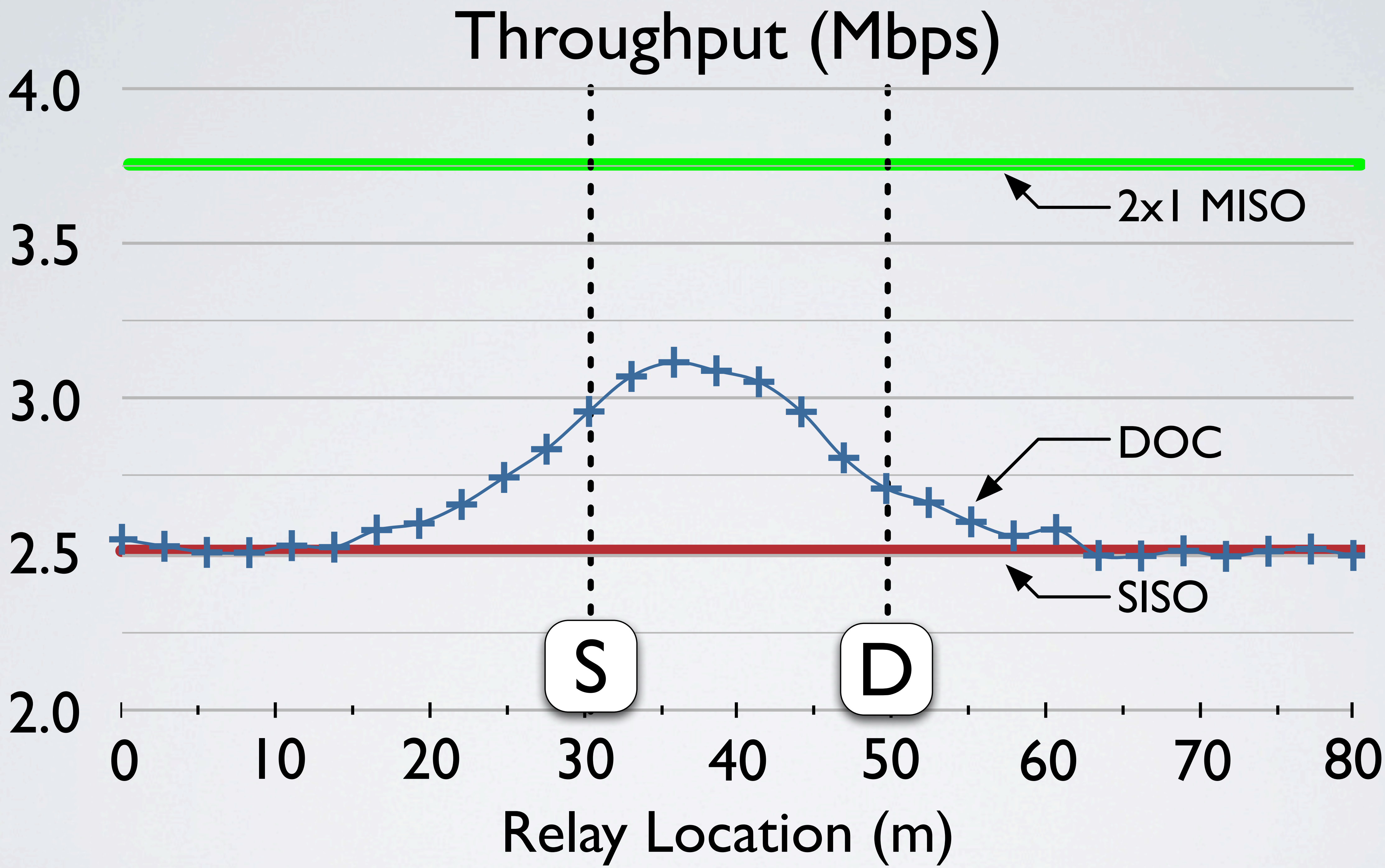


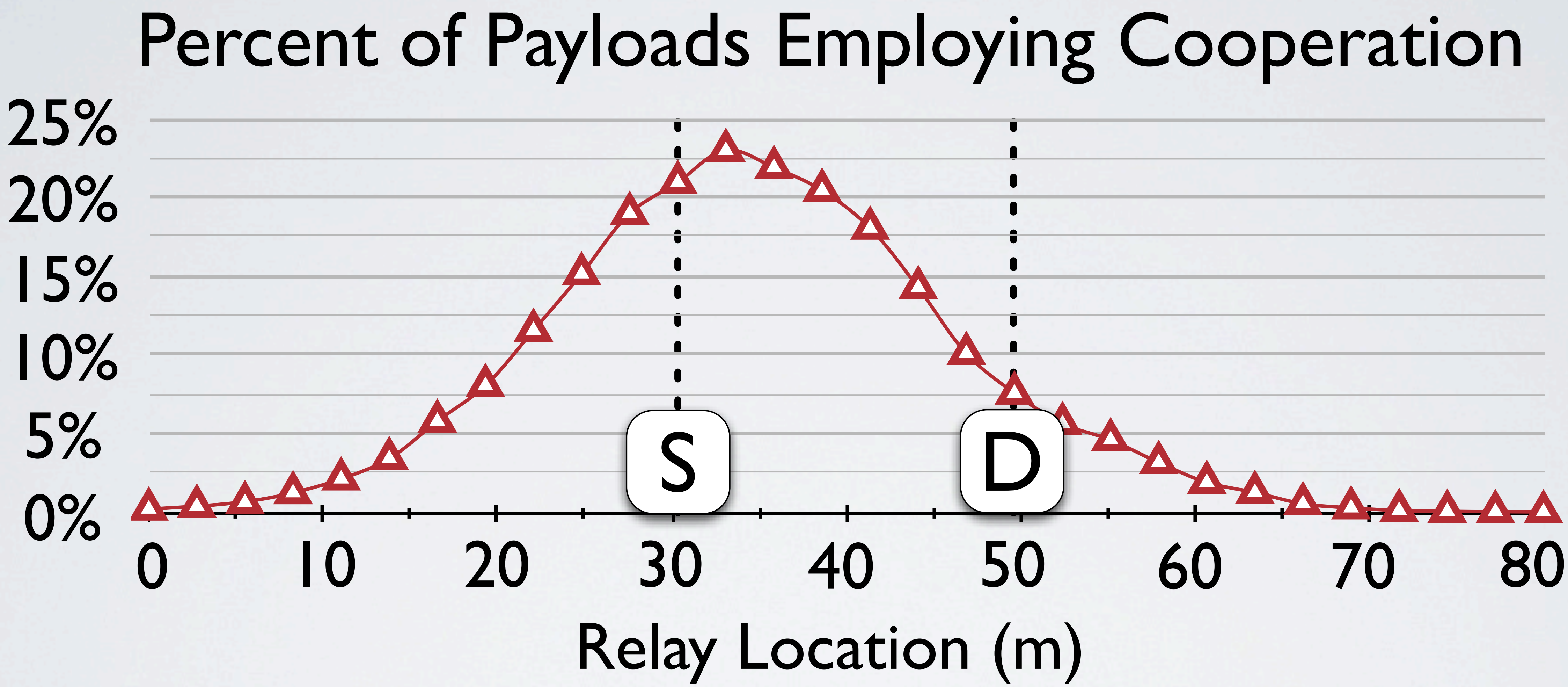
Ethernet Switch
Source WARP Node
Relay WARP Node
Destination WARP Node
Computer
H_{SR}
H_{RD}
H_{SD}
Wireless Channel Emulator

Throughput Improvement over CSMA/CA



- 2452 MHz RF
- AF relay
- 1400 byte packets
- TGn B channel model
- BPSK/QPSK header/payload
- No synchronization "cheats"


Throughput (Mbps)
4.0
3.5
3.0
2.5
2.0
2x1 MISO
DOC
SISO
S
D
0
10
20
30
40
50
60
70
80
Relay Location (m)


Percent of Payloads Employing Cooperation
25%
20%
15%
10%
5%
0%
S
D
0
10
20
30
40
50
60
70
80
Relay Location (m)

warp.rice.edu