Beyond the Bits: Cooperative Packet Recovery Using Physical Layer Information

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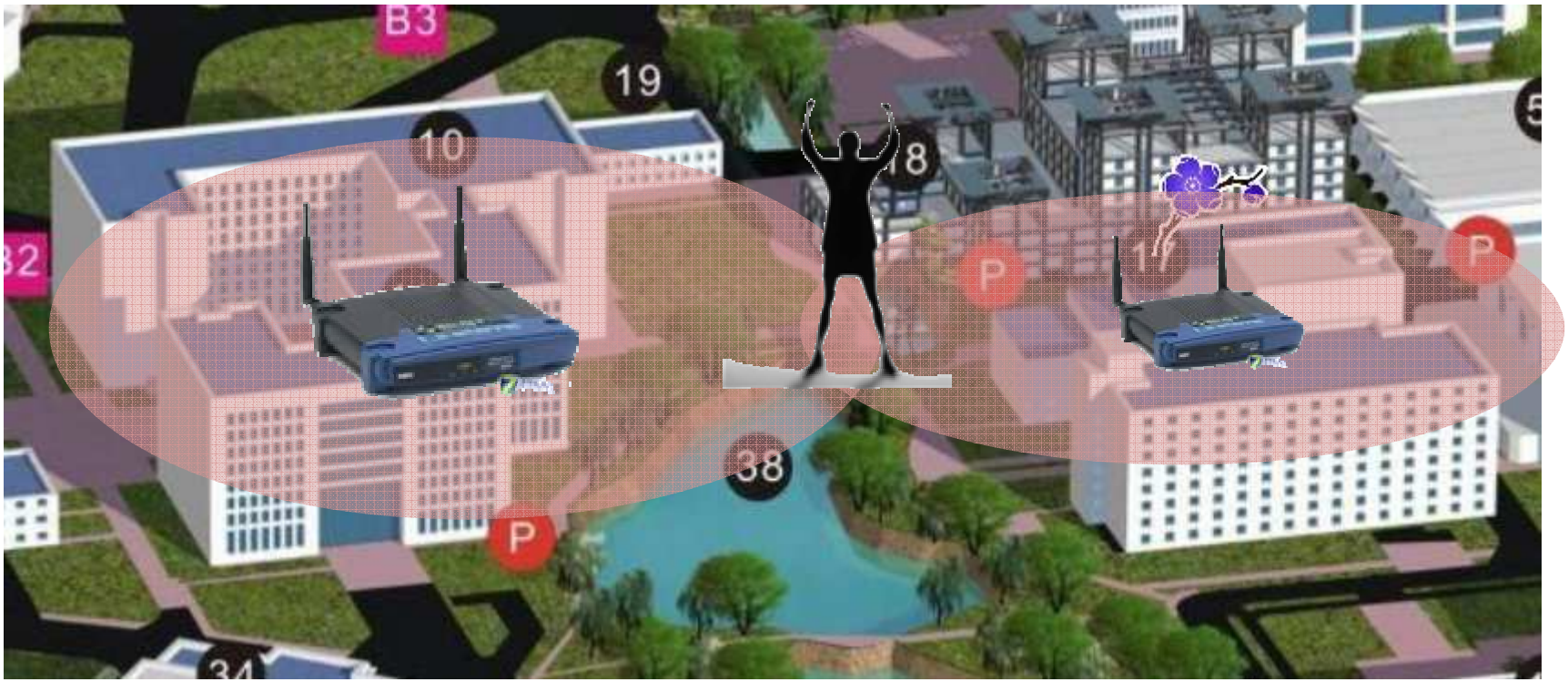
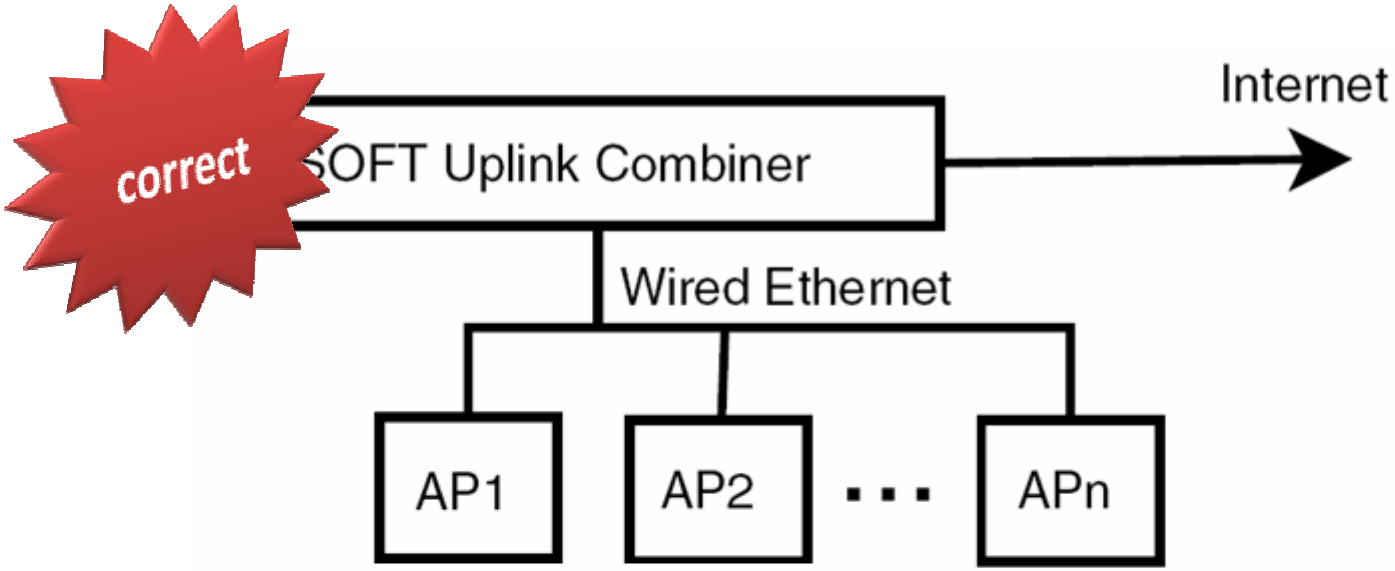
Introduction

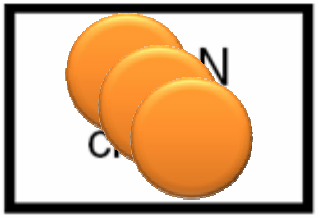
1. Cooperative Environment
2. Introduction
3. Conflict Problem
4. Physical Information

Cooperative Environment



Cooperative Environment



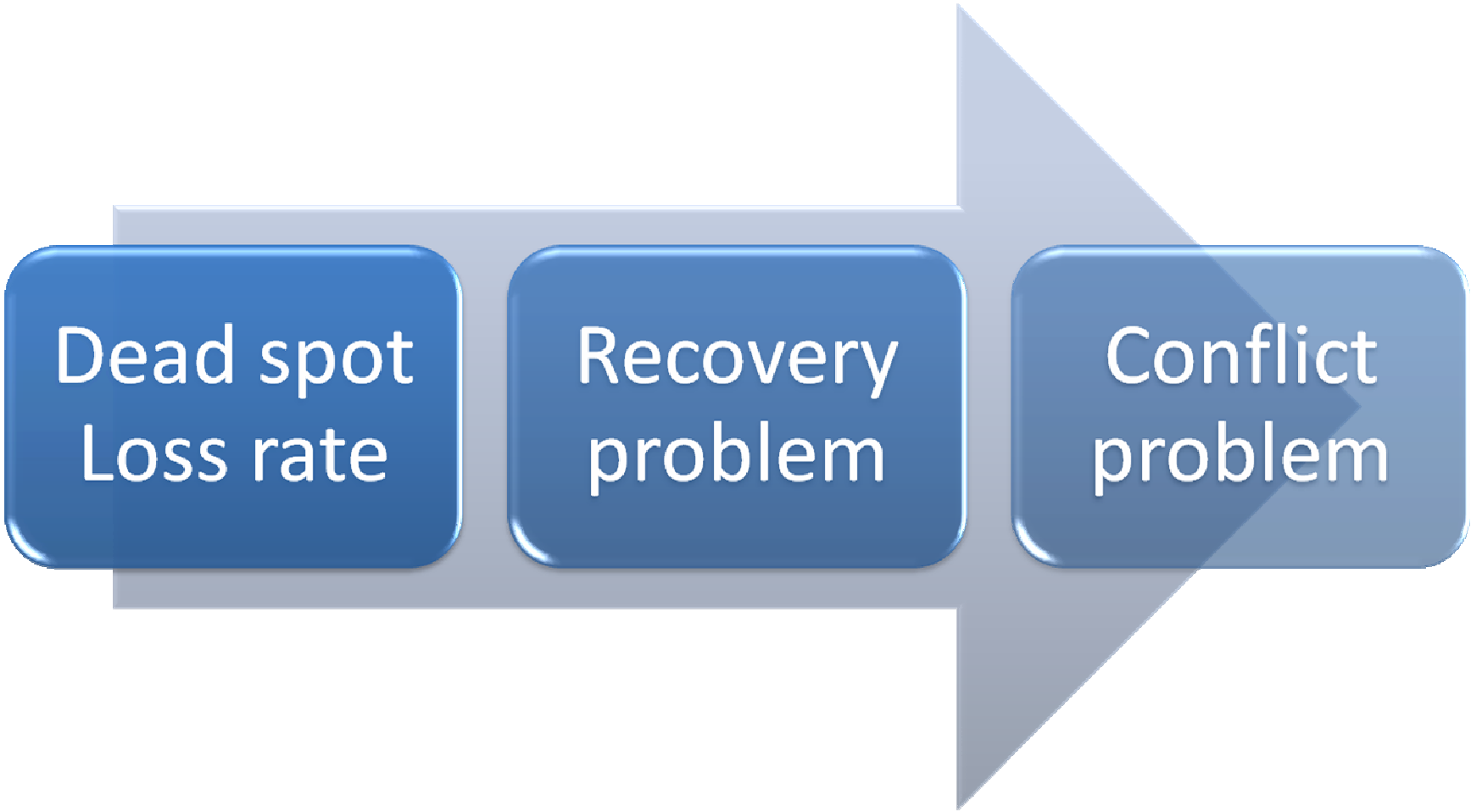


Introduction

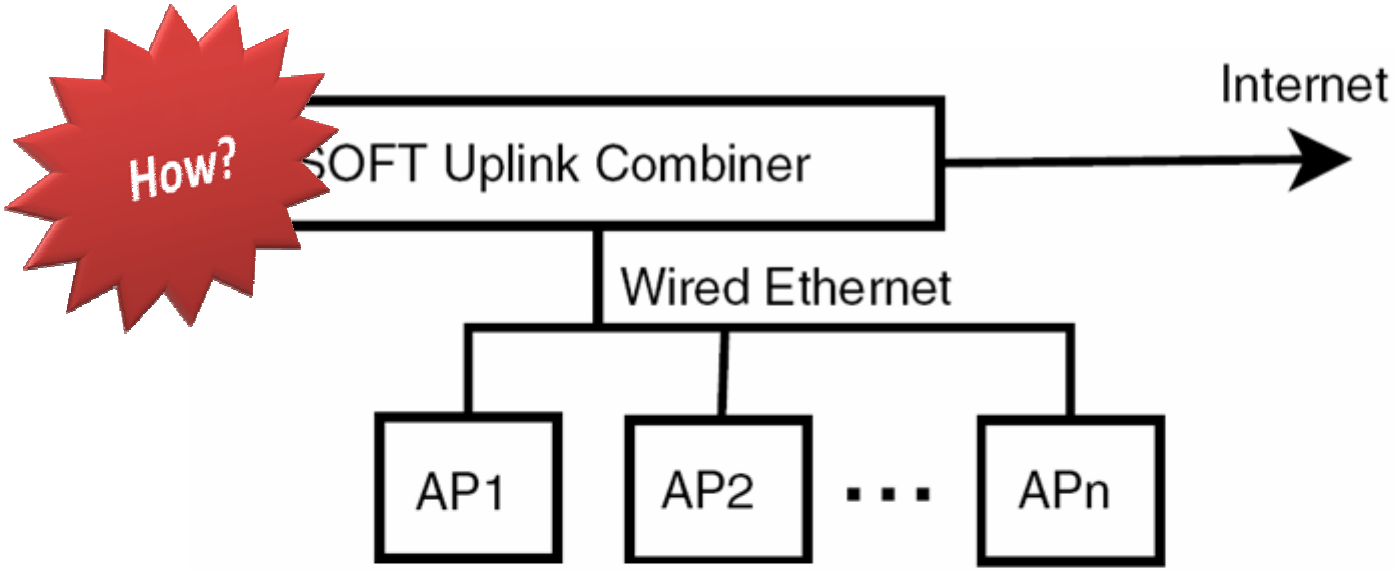
- WLAN experiences dead spots and high loss rates.

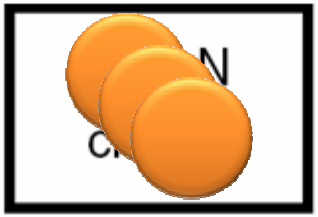
- These problems can be addressed by exposing information at the layer1.

Introduction

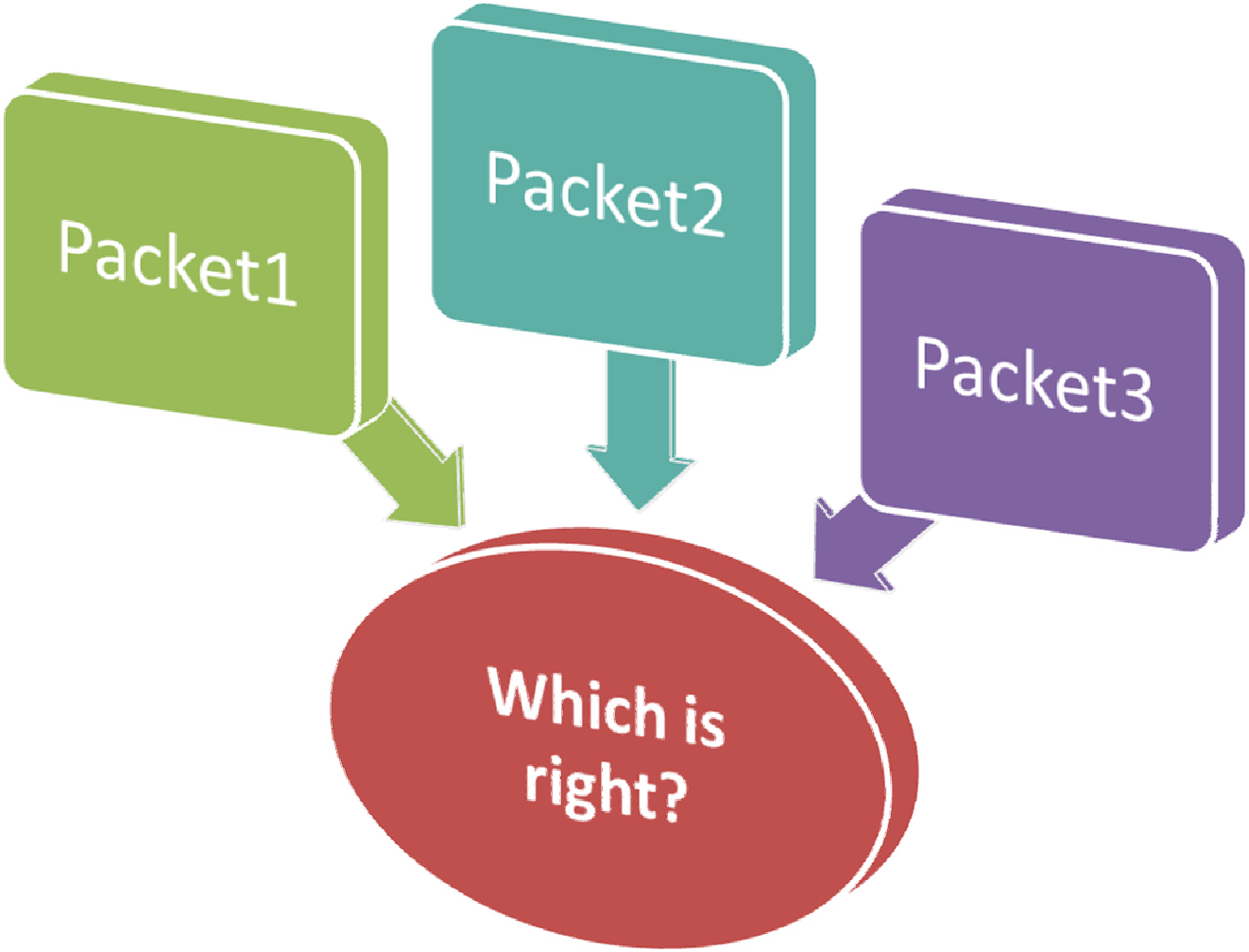


Conflict Problem

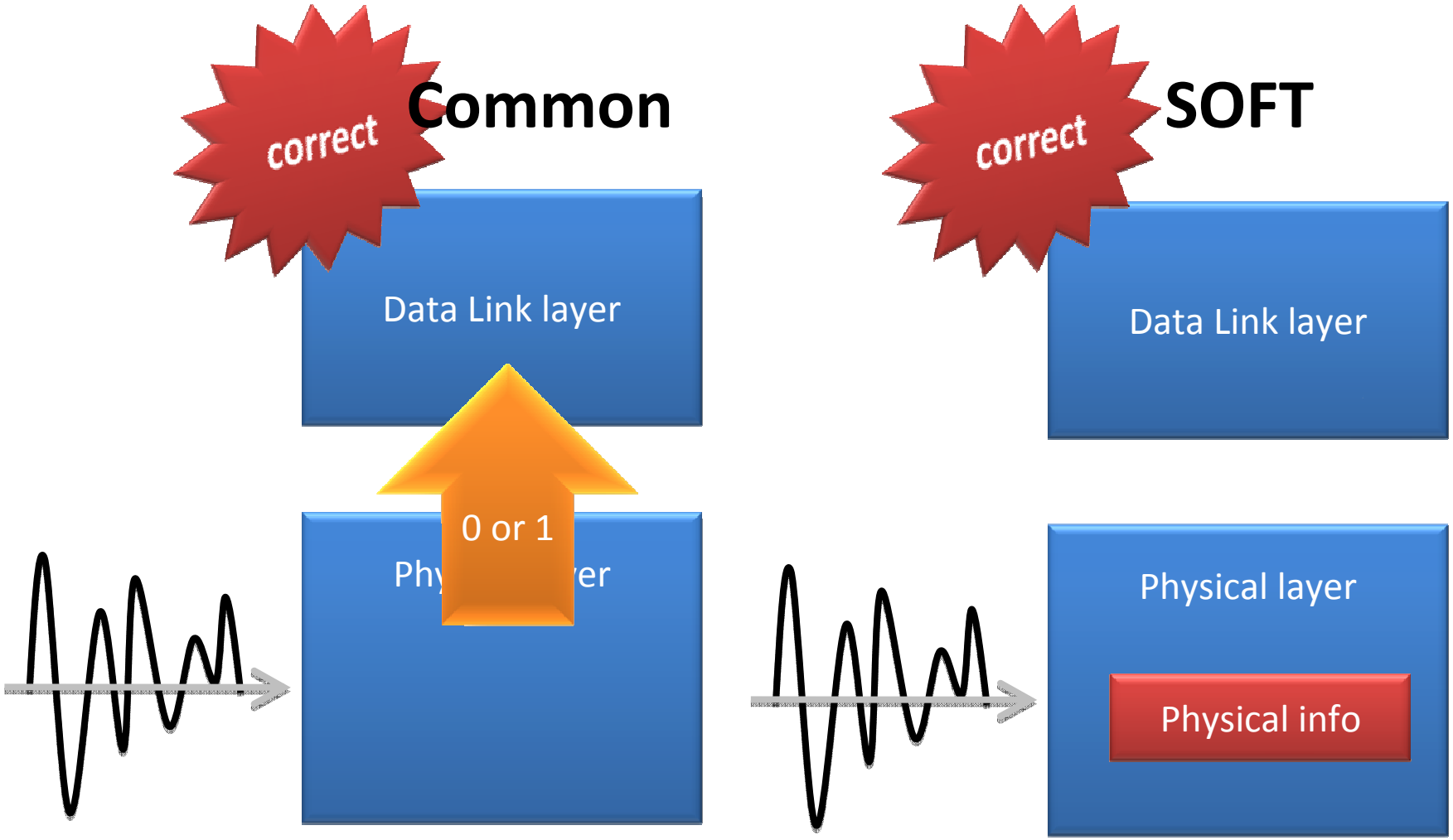




Conflict Problem



Physical Information



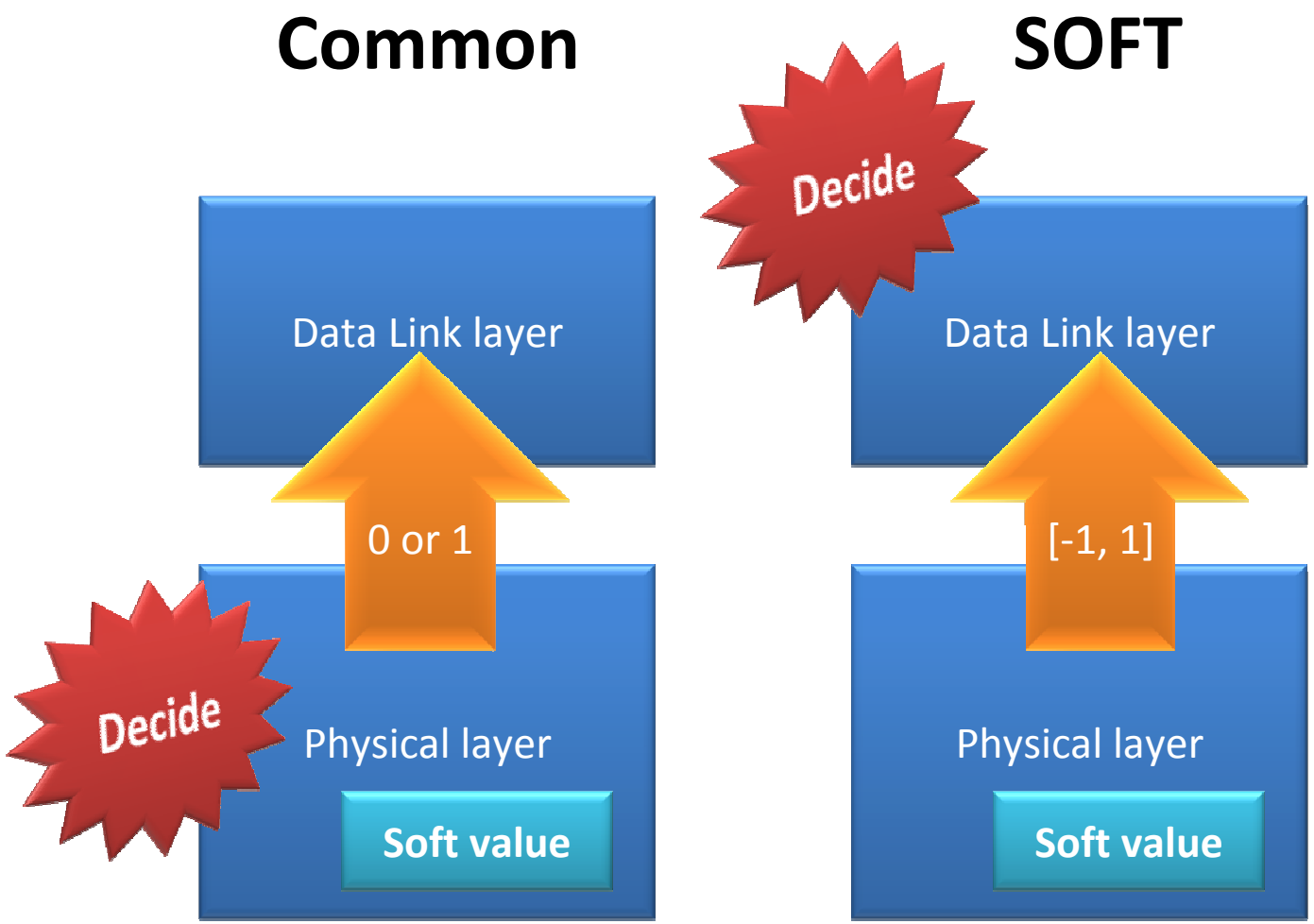
Physical Information

Decoder	Output	Example	Cost	Popularity
Hard-decision	0 / 1	[1, 0, 1, 0]=[1, 0, 1, 0]	lower	Popular
Soft-decision	range	[0.3, -0.3, 0.8, -0.1] =[1, 0, 1, 0]	higher	

soft value

Soft-decision decoding used at our physical layer

Physical Information



Soft Value

- For example
  Common physical layers return

1	0	0	1

SOFT returns

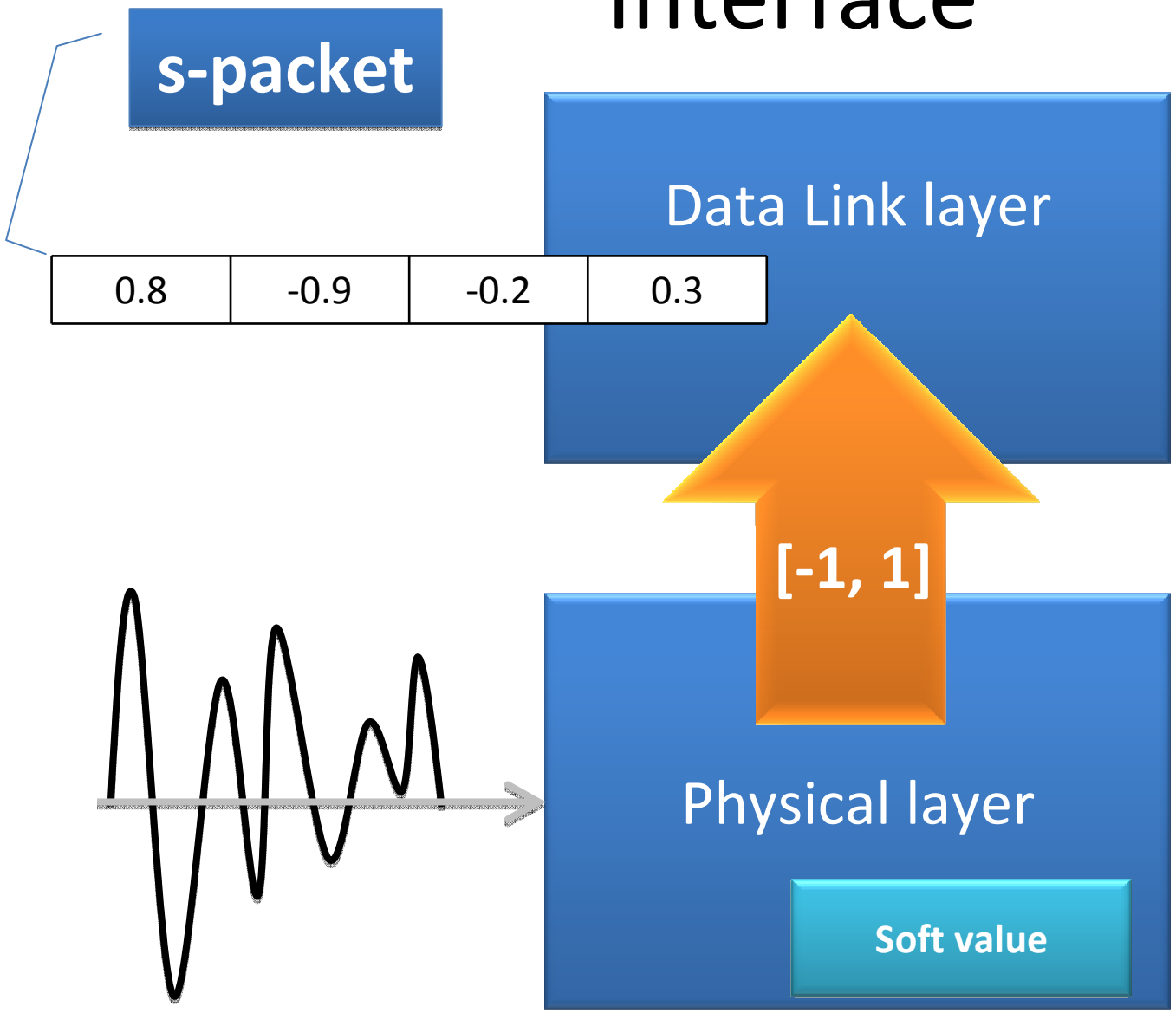
0.8	-0.9	-0.2	0.3

s-packet

SOFT Outline

1. Interface/Uplink/Downlink/ACK
2. Combining Algorithm
3. Evaluation
4. CONCLUSION

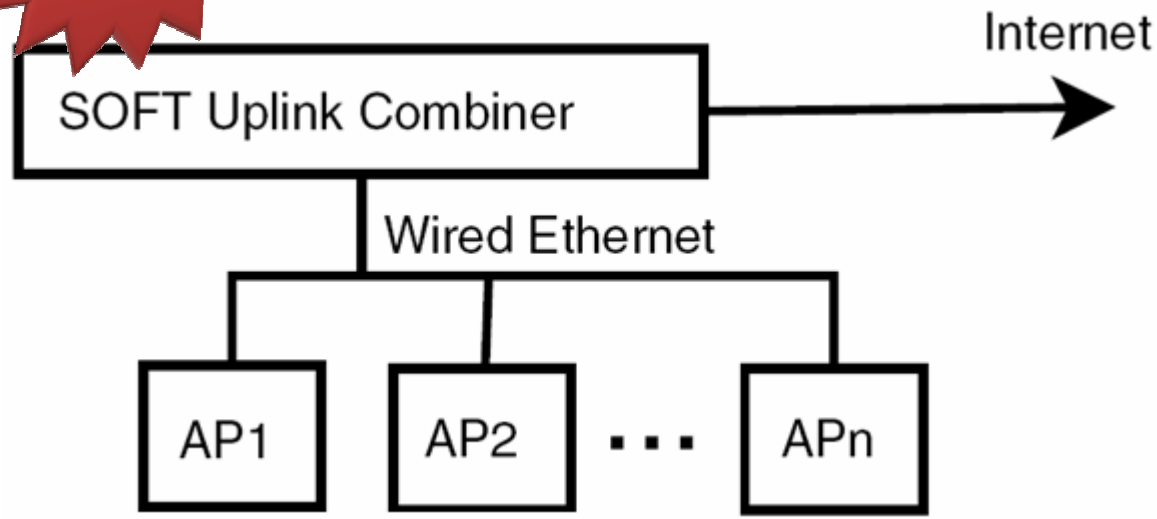
Interface

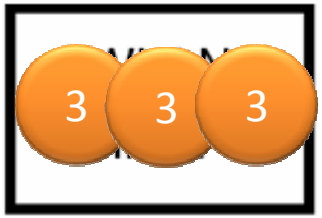

s-packet
0.8
-0.9
-0.2
0.3
Data Link layer
[-1, 1]
Physical layer
Soft value

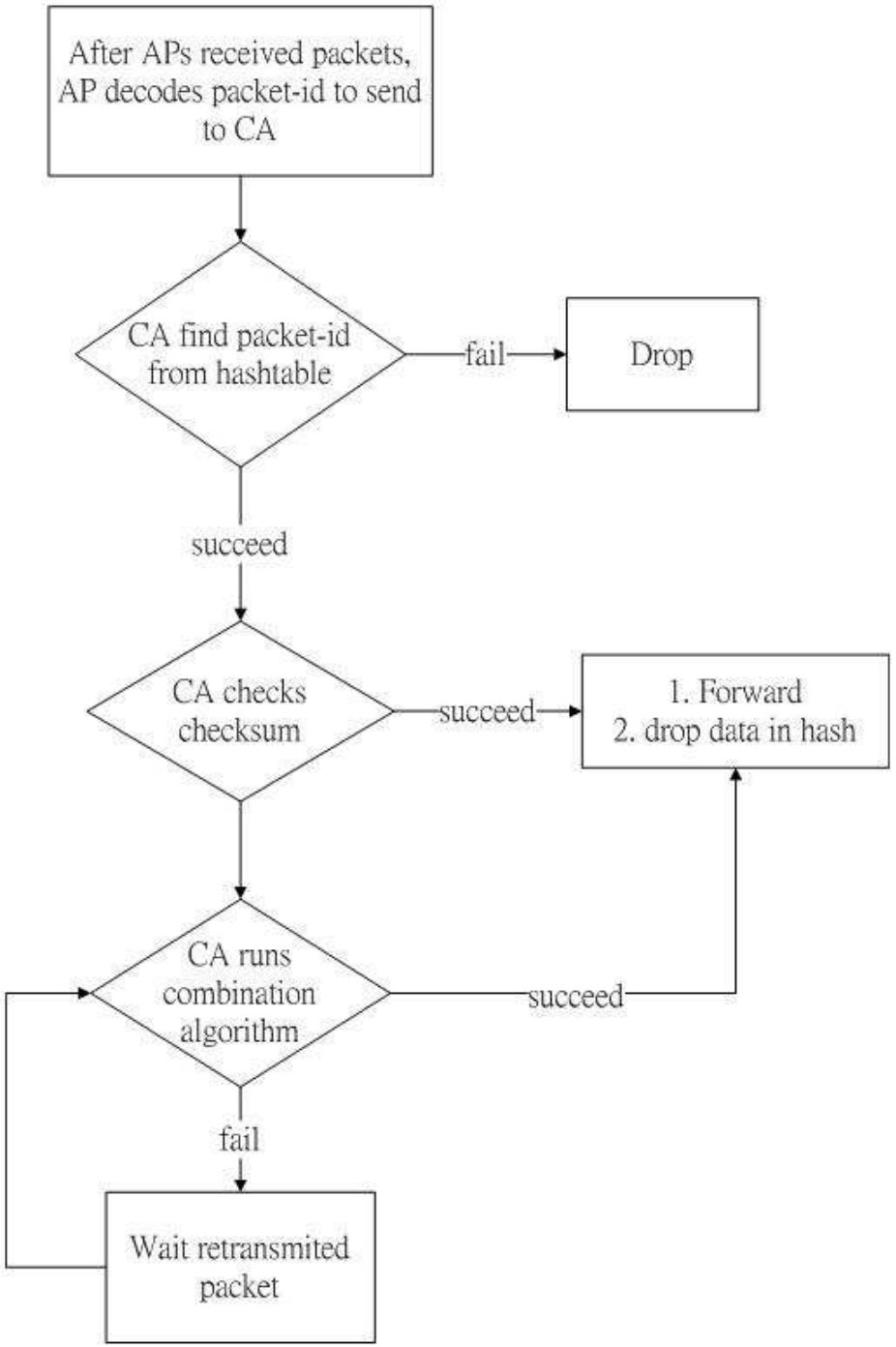
id	s-packet
3	

correct

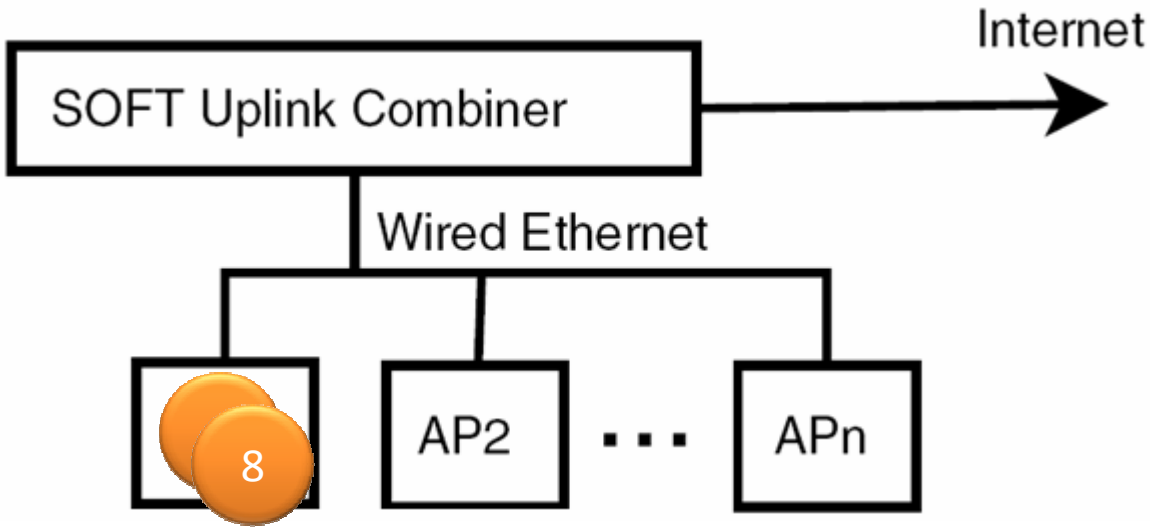
ink






After APs received packets, AP decodes packet-id to send to CA
CA find packet-id from hashtable
fail
Drop
succeed
CA checks checksum
succeed
1. Forward
2. drop data in hash
CA runs combination algorithm
succeed
fail
Wait retransmited packet

Downlink



WLAN client

Packet-id	S-packet
8	

correct

Combining Algorithm

- Problem :

  Let the SV corresponding to the i_{th} bit in these s-packets: 0.3, -0.1, -0.2.

  How does the algorithm decide whether the i_{th} bit is 0 or 1?

Combining Algorithm

- *LEMMA:*
  Let $y_1, \cdots, y_k$ be SVs that correspond to multiple receptions of the same bit over different AWGN channels.
  To maximize the recovery probability, one should map the bit to 0 or 1 according the following rule:

Combining Algorithm

- Our strategy uses the sum of SVs weighted by the noise variance at their corresponding AP.

$$if \ \sum_i \frac{y_i}{\sigma^2} \geq 0, then \ \text{"1"}, \text{otherwise} \quad \text{it is a "0".}$$

Implementation

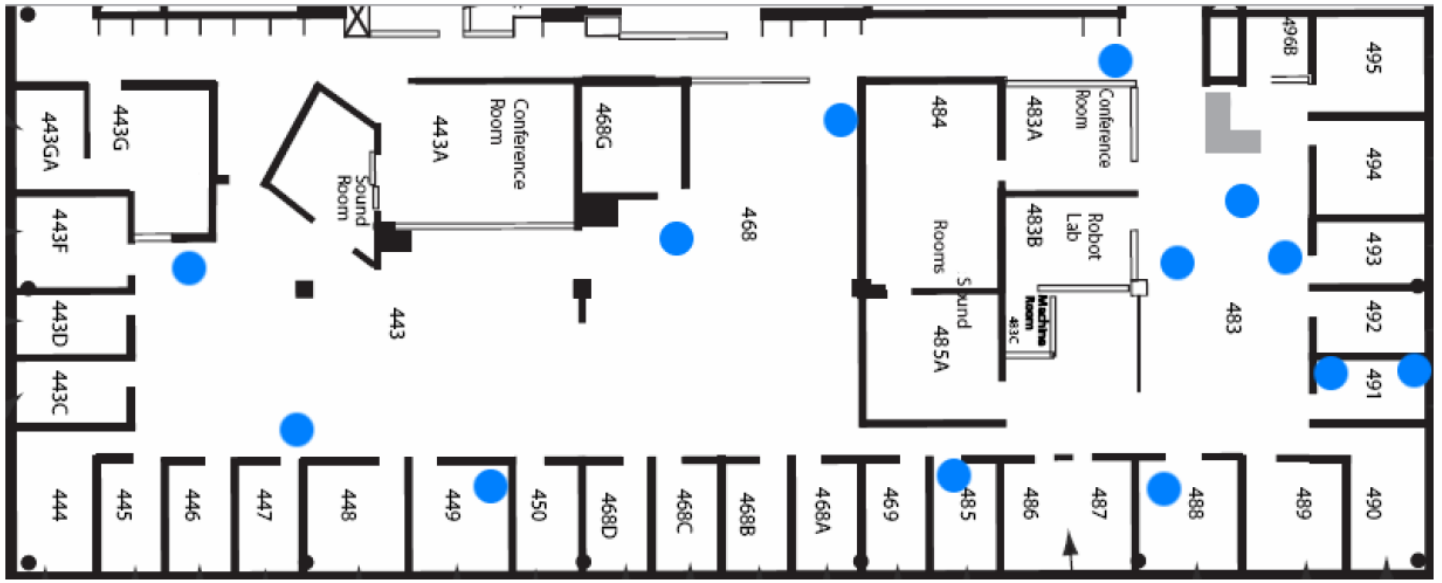
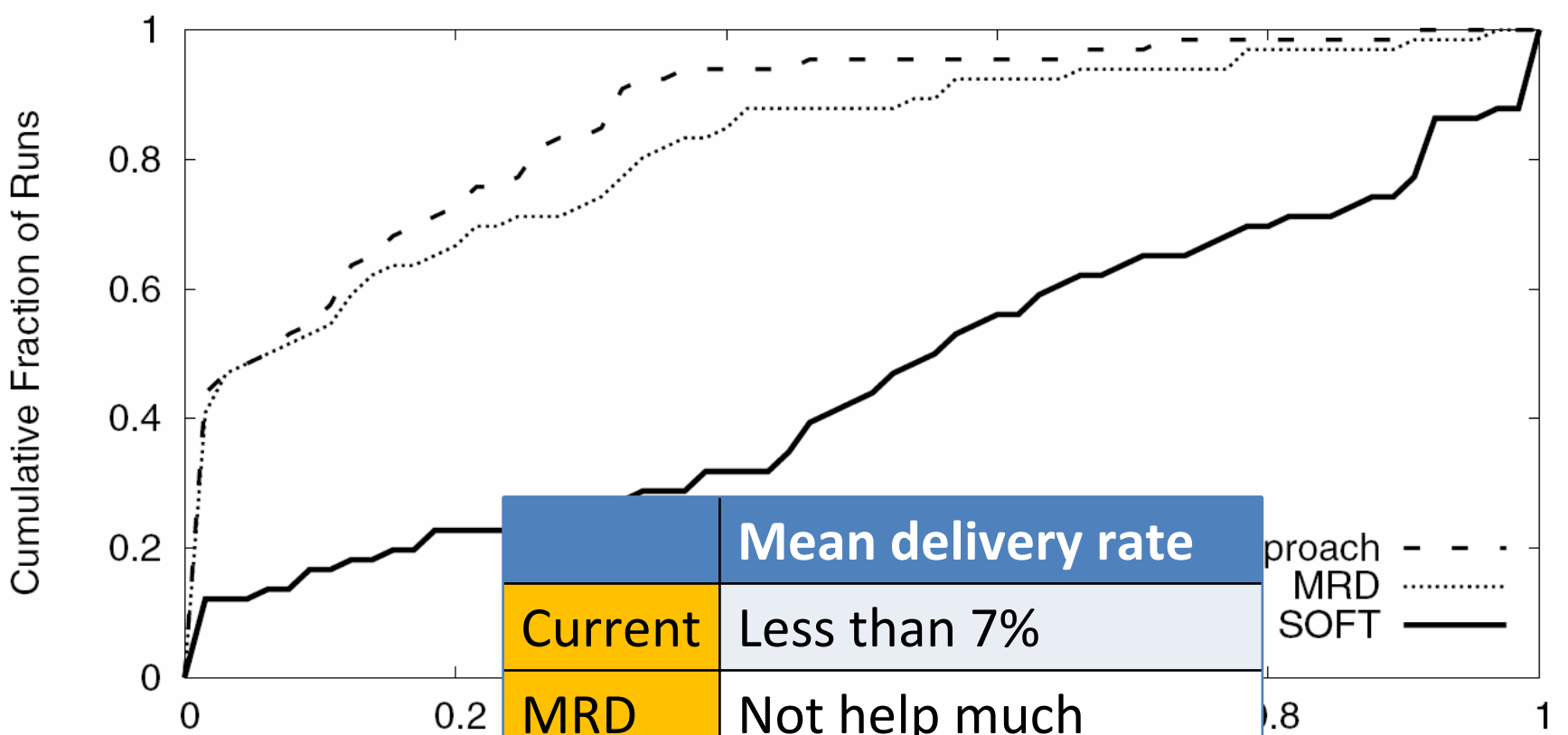


Figure 4: Testbed Topology. The figure shows the testing environment. The dots mark the locations of the GNURadio nodes.

Implementation

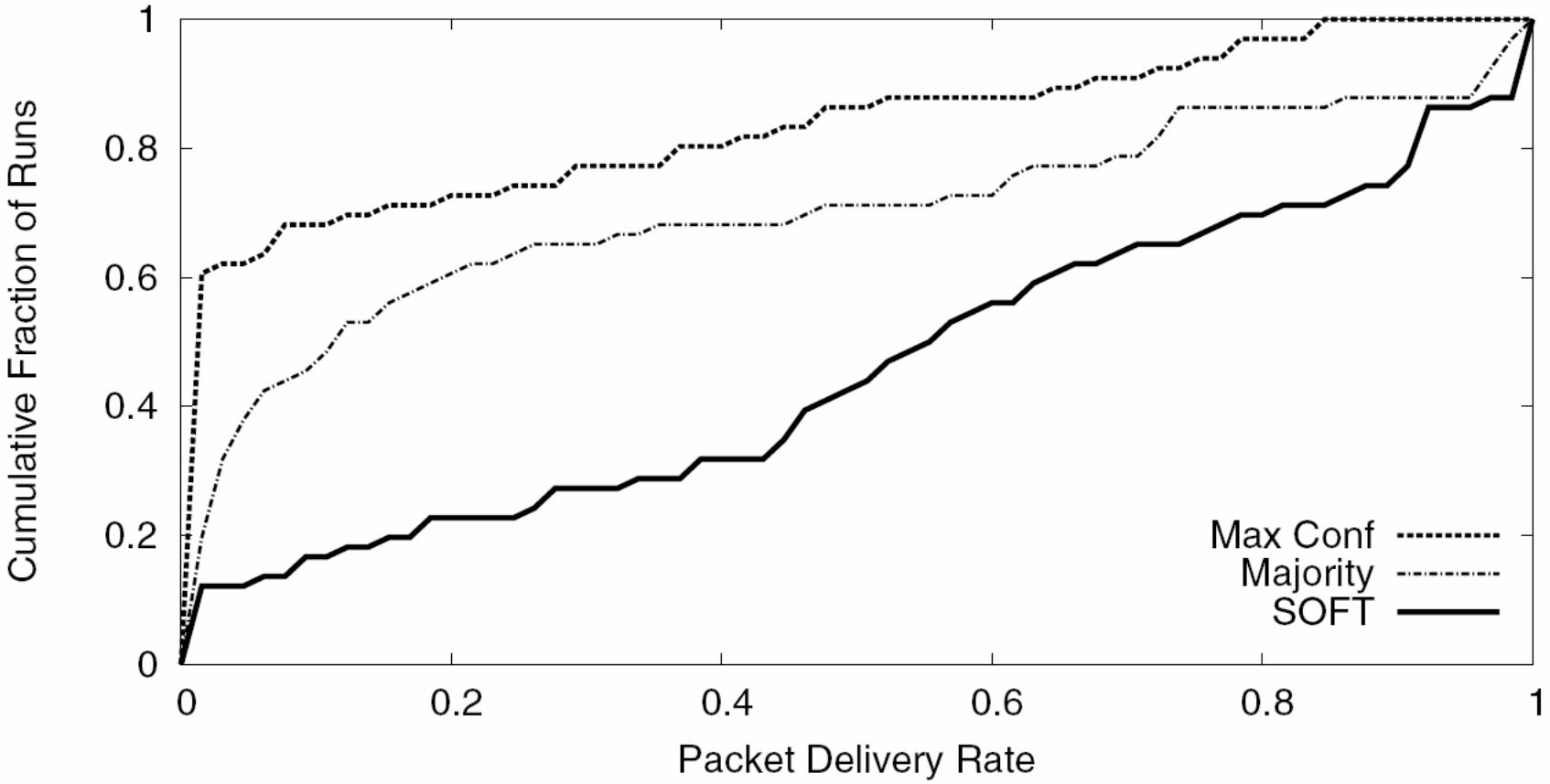
Uplink – Spatial Diversity	
APs	3
sender	Randomly chosen sender
Number of packets	500
Packet size	1500B

Downlink – Time Diversity	
Sender-receiver pair	Randomly picked
Number of packets transferred	500 packets

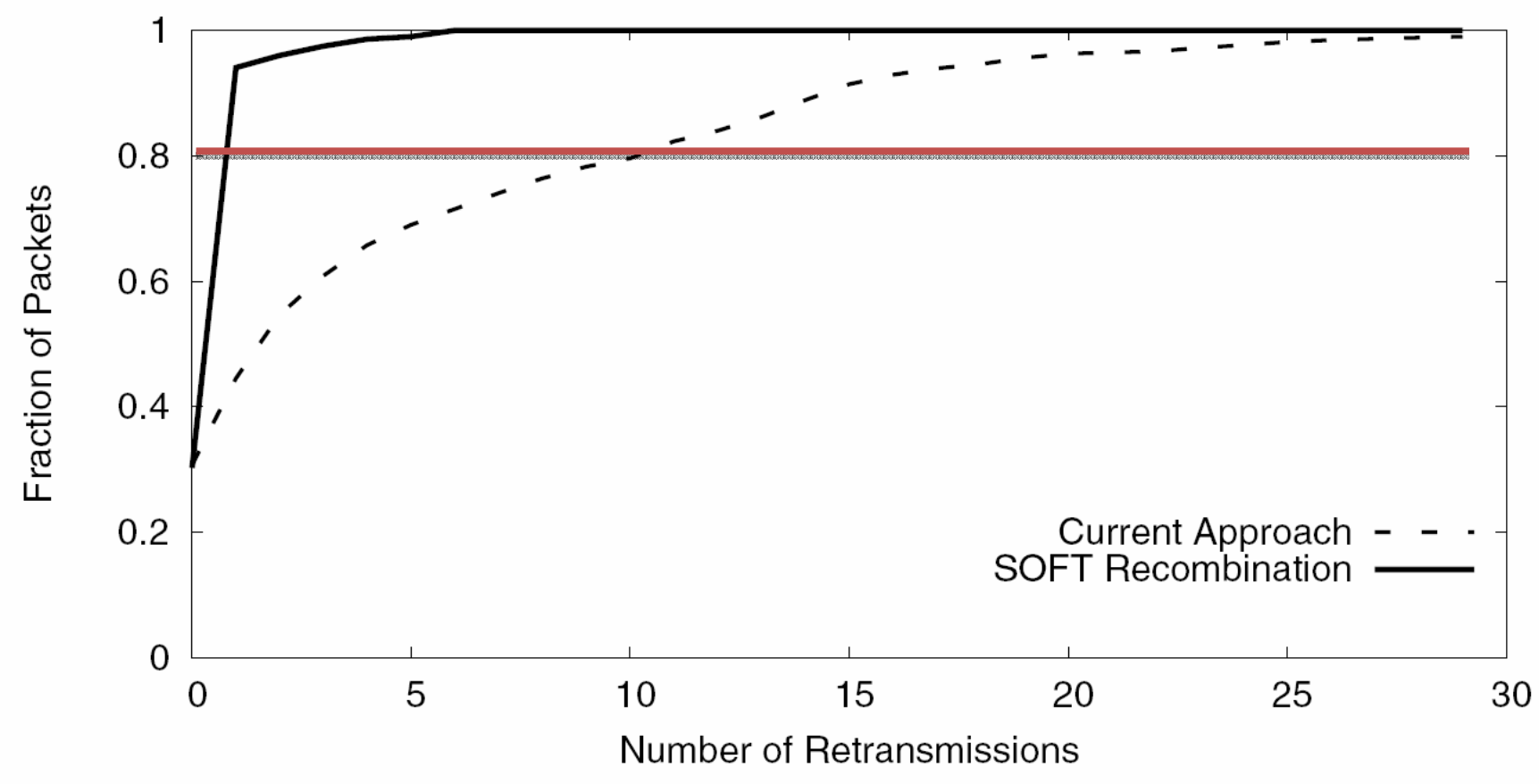


	Mean delivery rate
Current	Less than 7%
MRD	Not help much
SOFT	62%

Uplink


Cumulative Fraction of Runs
Packet Delivery Rate
0
0.2
0.4
0.6
0.8
1
Max Conf
Majority
SOFT

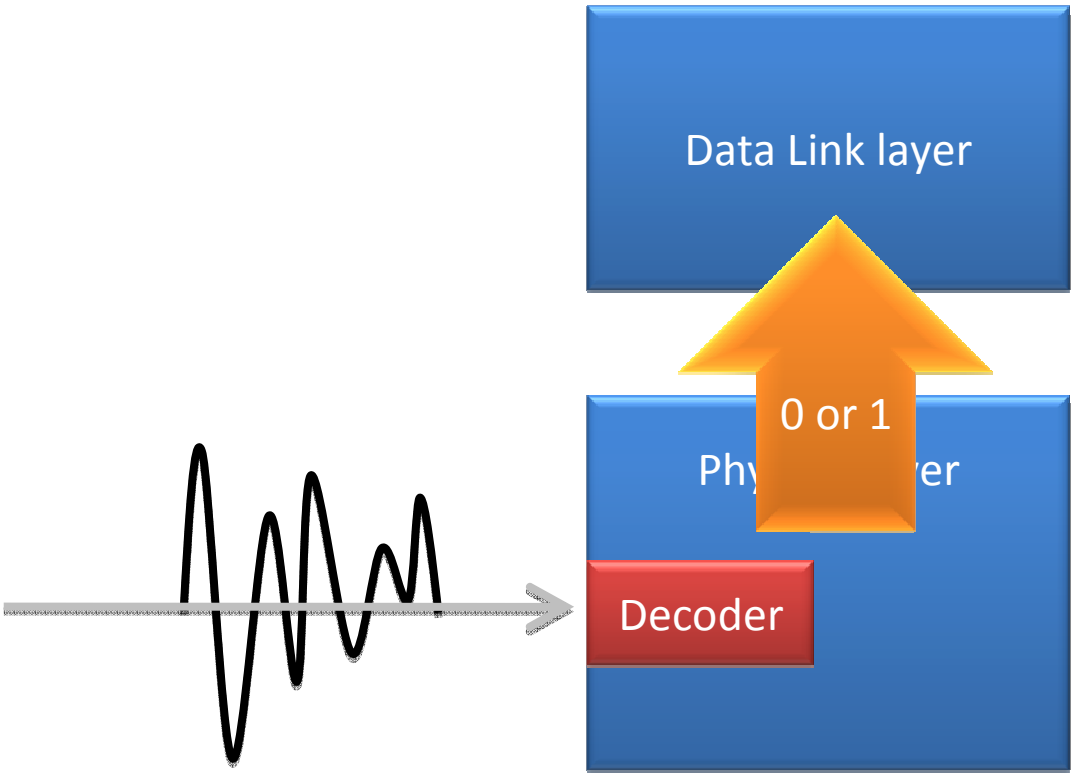
Downlink


Fraction of Packets
1
0.8
0.6
0.4
0.2
0
0
5
10
15
20
25
30
Number of Retransmissions
Current Approach
SOFT Recombination

Conclusion

- Beyond the Bits: Cooperative Packet Recovery Using Physical Layer Information

Hard-Decision Decoder



Soft-Decision Decoder