

Efficient Cooperative Relaying in Wireless Multi-Hop Networks with Commodity WiFi Hardware

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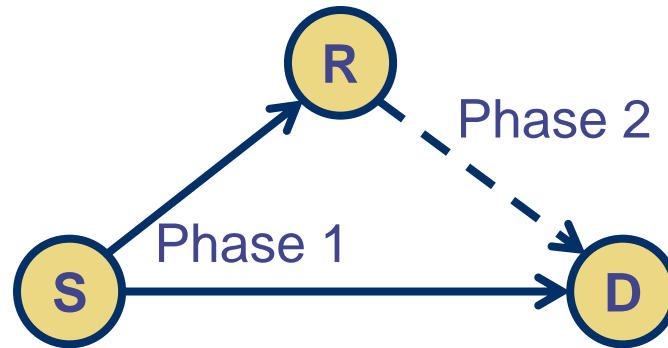
Overview

- Cooperation protocol
 - Two-for-one cooperation
- Driver modification
- Testbed setup
- Results
 - Simulation vs. reality



Basic wireless cooperation

- Relay aids source-to-destination transmission

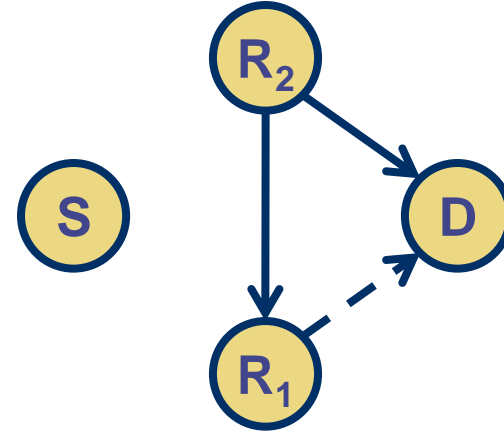
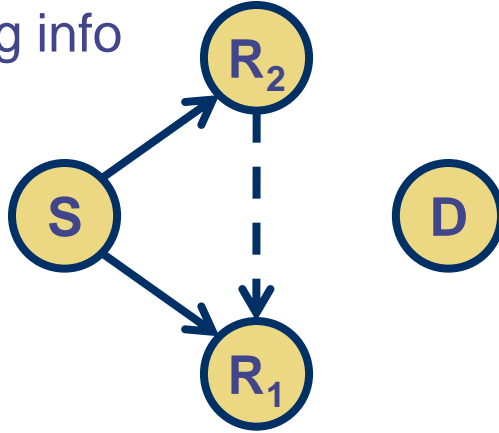


- Combine messages at the destination
- Spatial diversity
 - Direct and relay channel
- Reduced packet error rate
 - Reduced average packet delivery time

What is two-for-one cooperation?

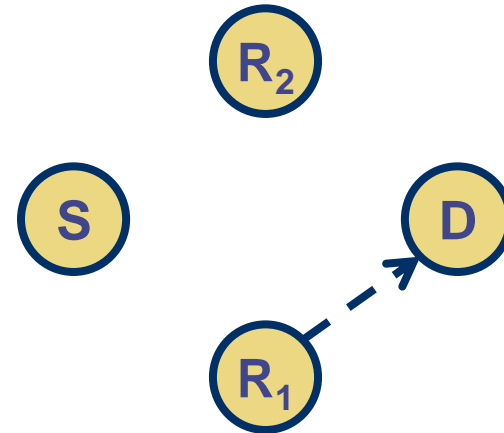
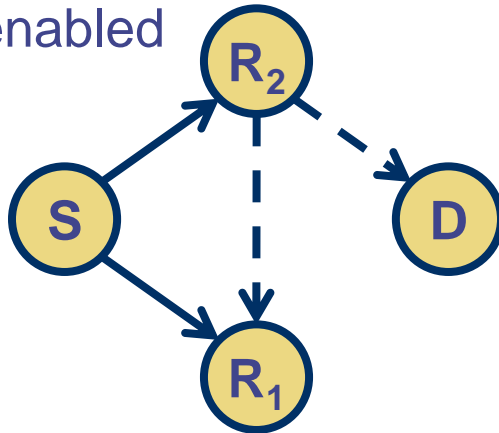
Cooperative Triangles (CTR)

- No routing info



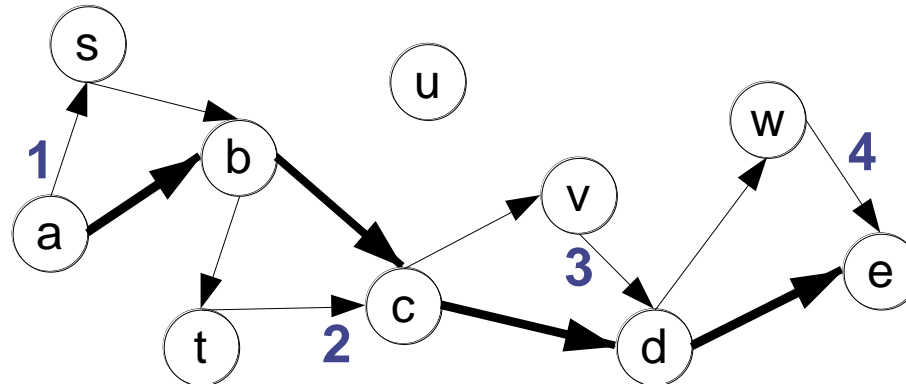
Two-for-one (Weak Full Diamond (WFD))

- Routing enabled



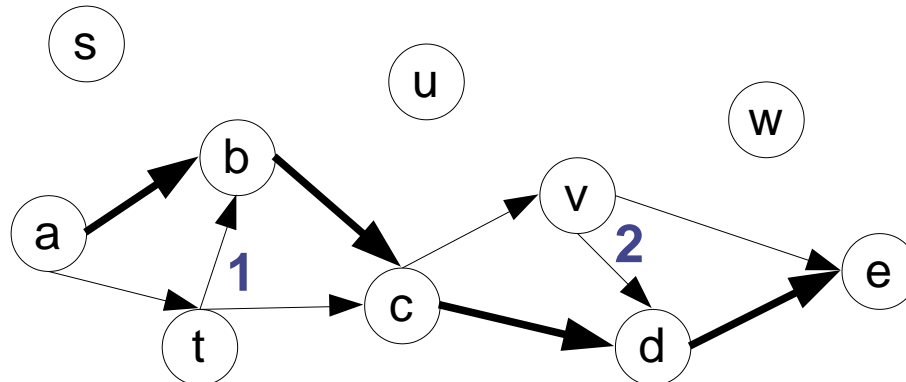
Multi-hop routing with cooperation

- Non-cooperative relay (GTR/CR)



4 relay transmissions

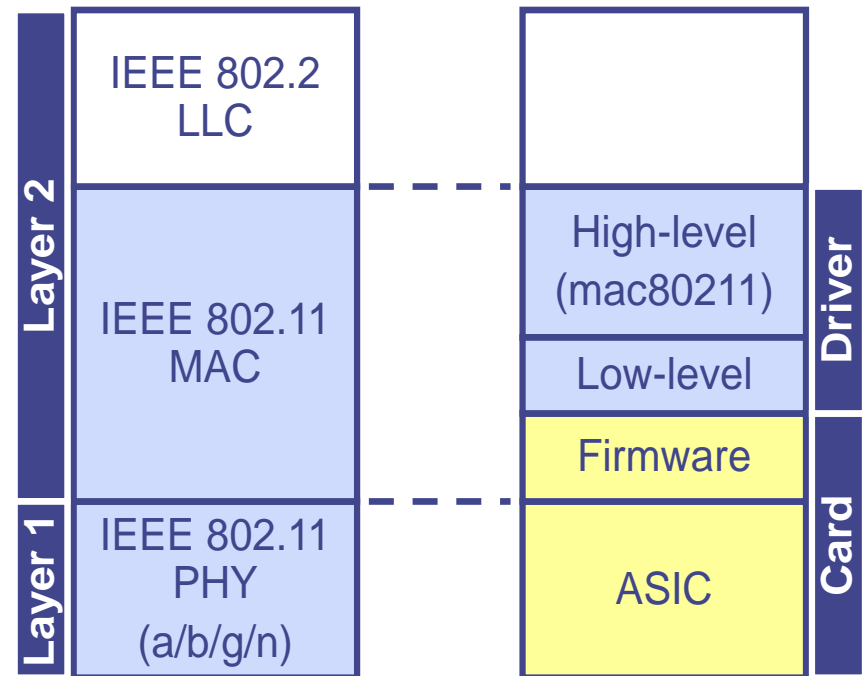
- New: Two-for-one cooperation → fewer transmissions



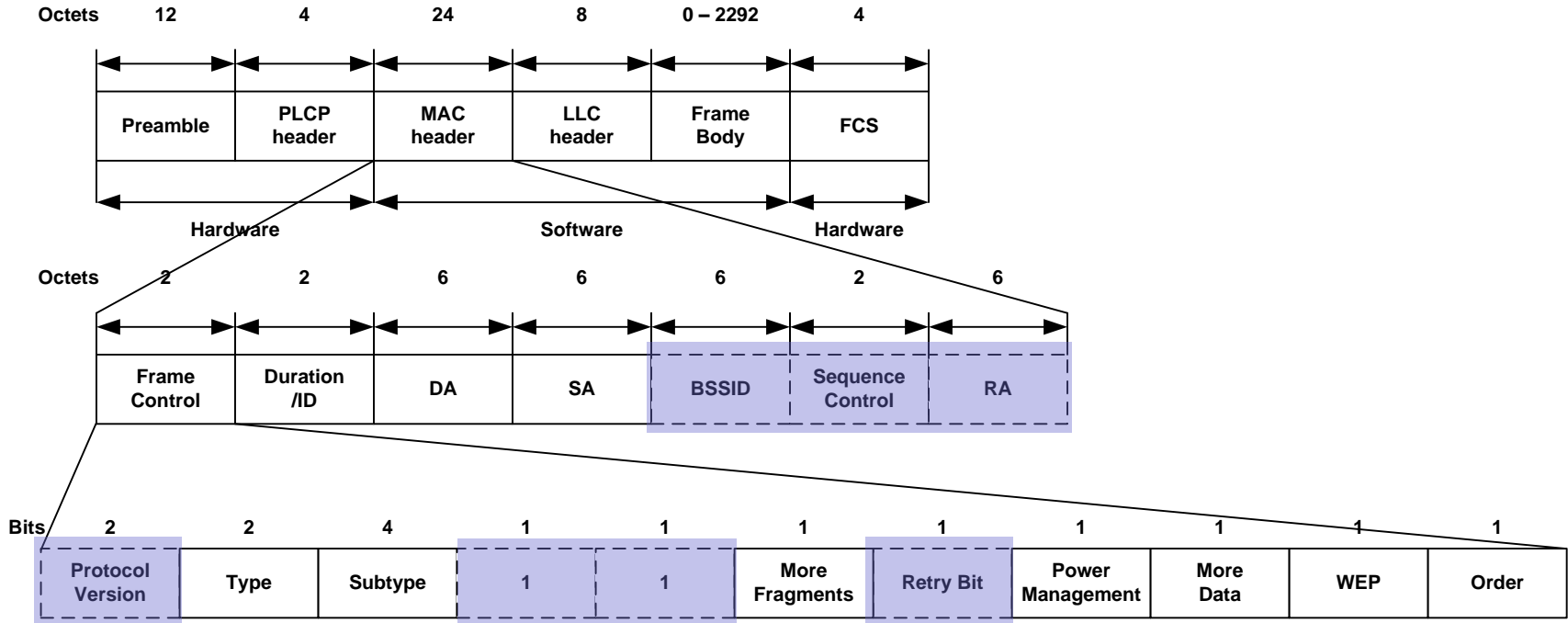
2 relay transmissions

Driver modification

- We cannot modify everything
 - ASIC off limits
 - Closed source firmware
 - No PHY access
 - No Maximum Ratio Combining
- We can modify the driver
 - Manipulate payload
 - Send extra messages
 - Want to conform to IEEE 802.11 standard
 - Packet Selection Combining (PSC)



Modified header fields



- Dashed fields modified for two-for-one cooperation
 - Protocol version from 00 to 01 to indicate modification
 - Forth address field for relay address

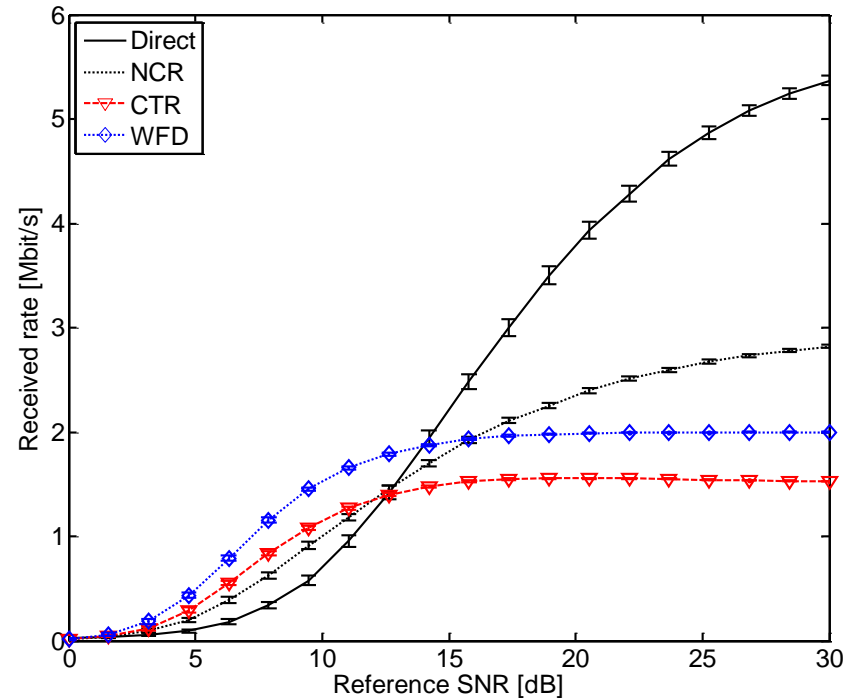
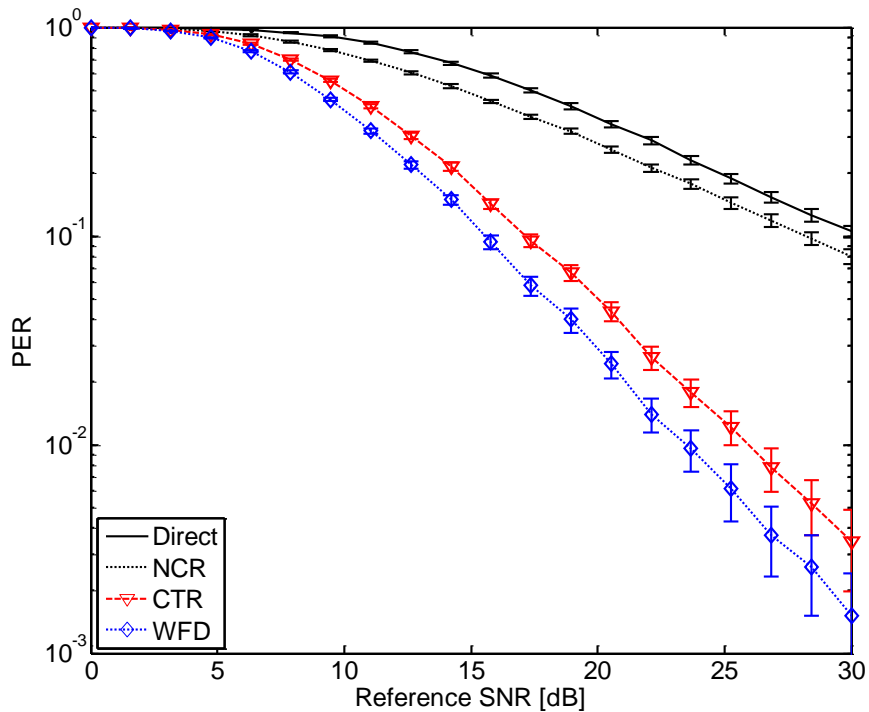
Diamond cooperation test bed

- Intermediate step to sensor nodes
- Commodity hardware, modified ath5k linux driver



Simulation results

- Symbol-wise Rayleigh fading, AWGN
- 1024 byte packets
- Movement speed of 1 m/s

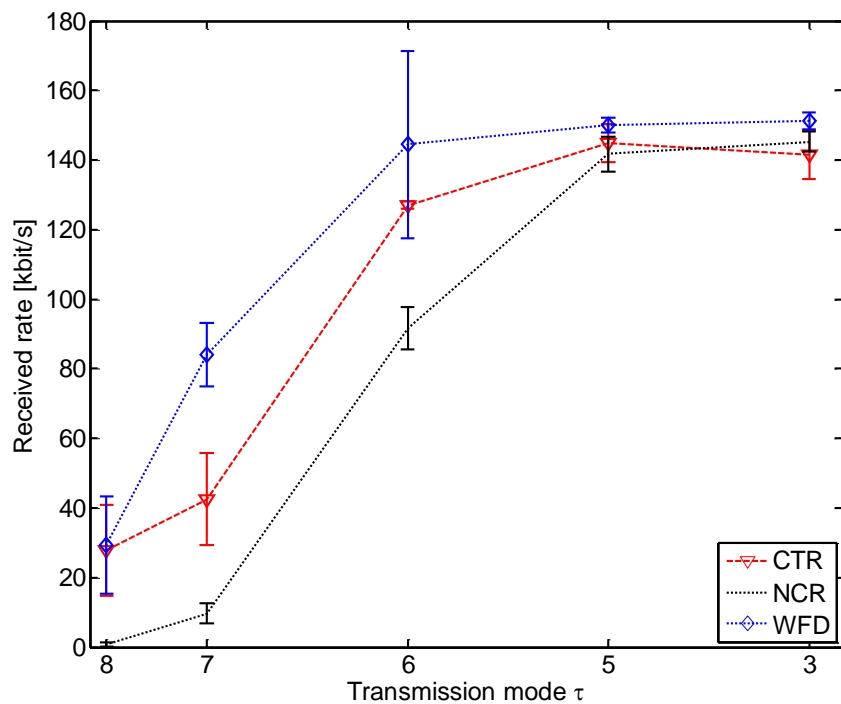


Real hardware measurements

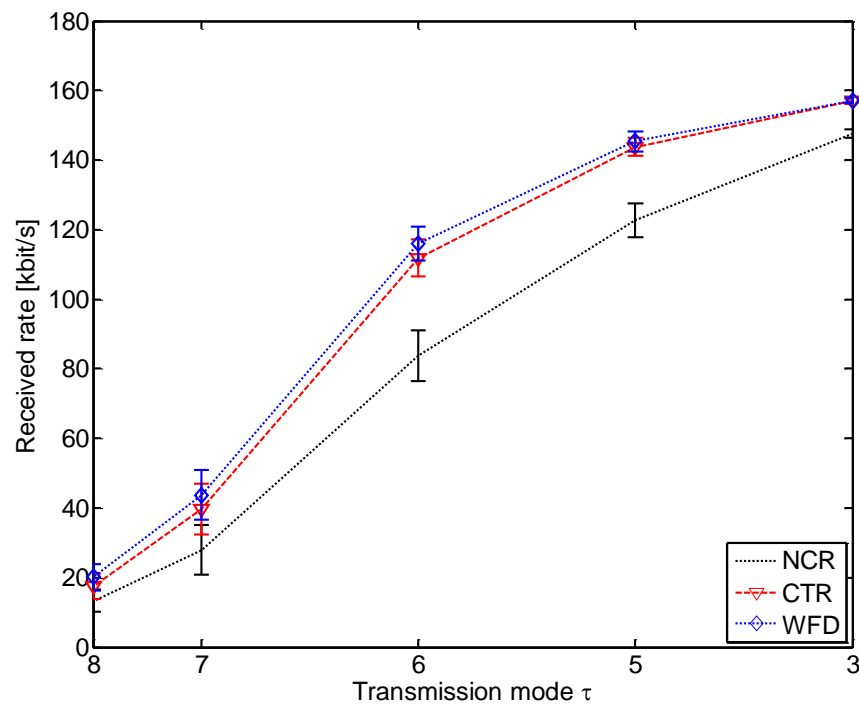
- Measurements resemble simulation
- Two-for-one cooperation benefits more on real hardware

TABLE I
TRANSMISSION MODES OF THE IEEE 802.11A/G PHYSICAL LAYER [10]

Mode τ	Modulation	Coding rate R_c	Coded bits per OFDM symbol	Data bits	Data rate [Mbit/s]
1	BPSK	1/2	48	24	6
2	BPSK	3/4	48	36	9
3	QPSK	1/2	96	48	12
4	QPSK	3/4	96	72	18
5	16-QAM	1/2	192	96	24
6	16-QAM	3/4	192	144	36
7	64-QAM	2/3	288	192	48
8	64-QAM	3/4	288	216	54



Measurement



Simulation



Conclusions

- Two hop cooperation benefits from routing information
 - More knowledge → fewer transmissions
 - Lower error rates
- Hardware restrictions on commodity hardware
 - Can be overcome
- Cooperation enabled WiFi driver available
 - <http://www.sourceforge.net/projects/coopwifi/>

Questions?

