

---

# On the Effectiveness of Cooperative Diversity in Ad Hoc Networks: A MAC Layer Study

---

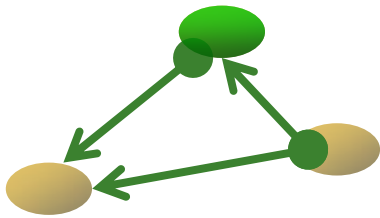
Haitao Zheng, *Microsoft Research Asia*

Yan Zhu, *Tsinghua University*

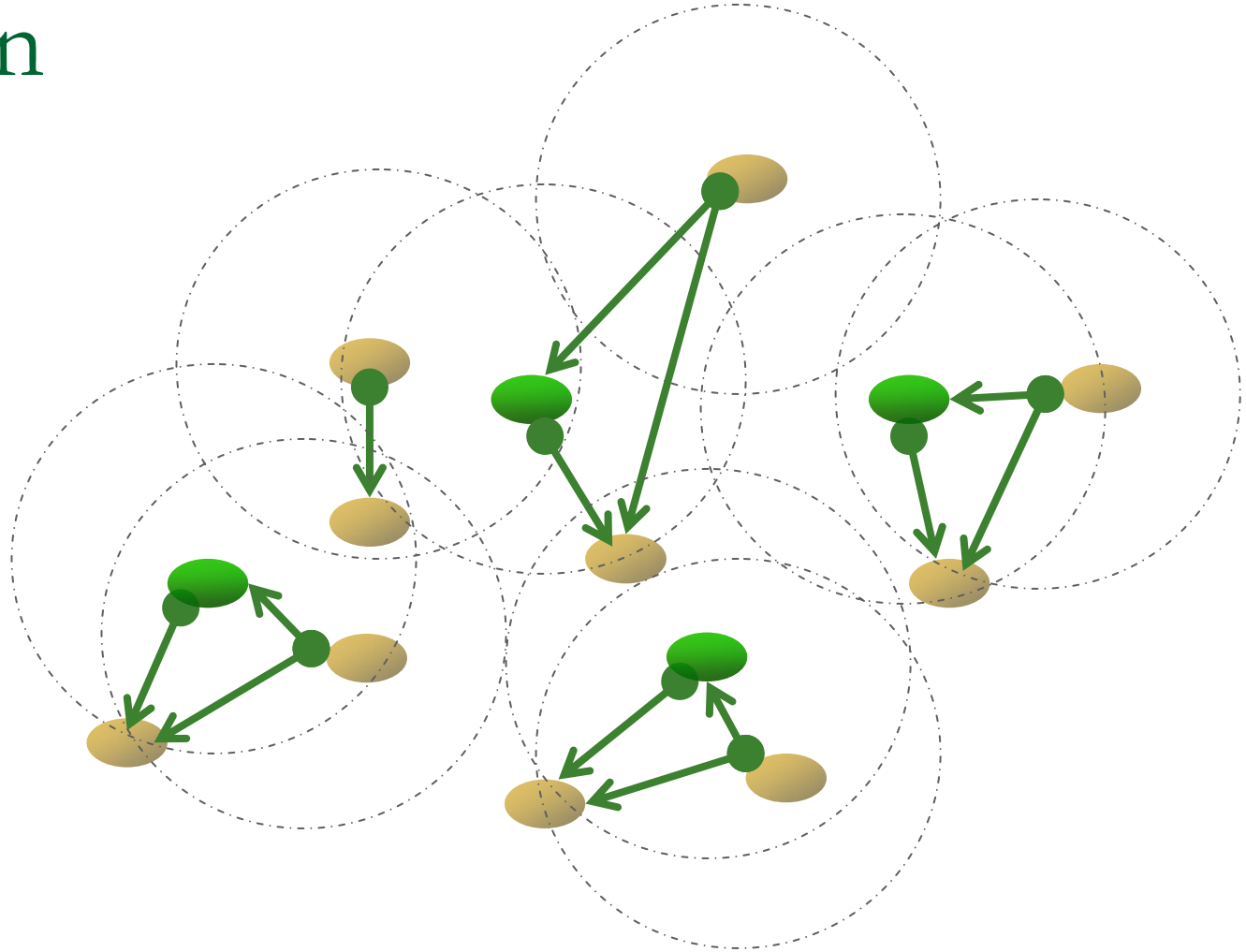
Cong Shen, *Univ. of California Los Angeles*

Xiaodong Wang, *Columbia University*

# Motivation


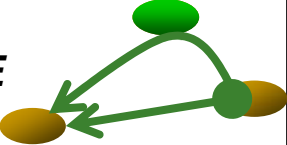
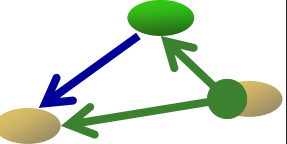
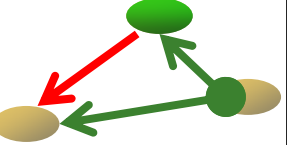
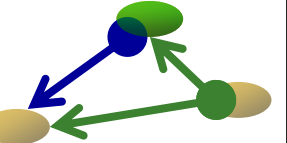


***Cooperative Relay  
for a single  
transmission  
Lots of Research!***

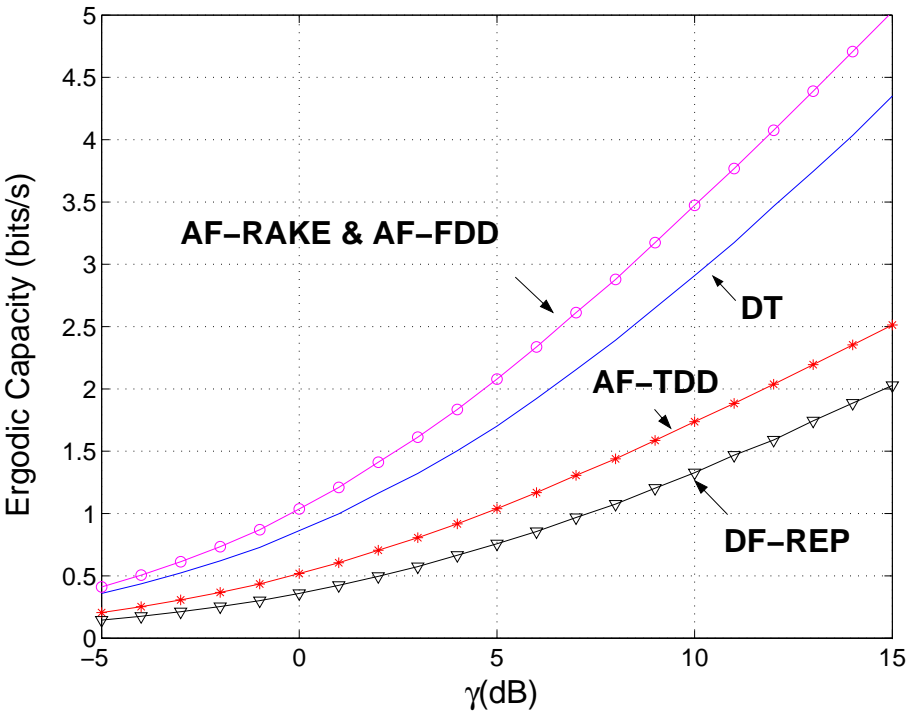


***Cooperative Relay in a network, Does the single  
link conclusion still hold?***

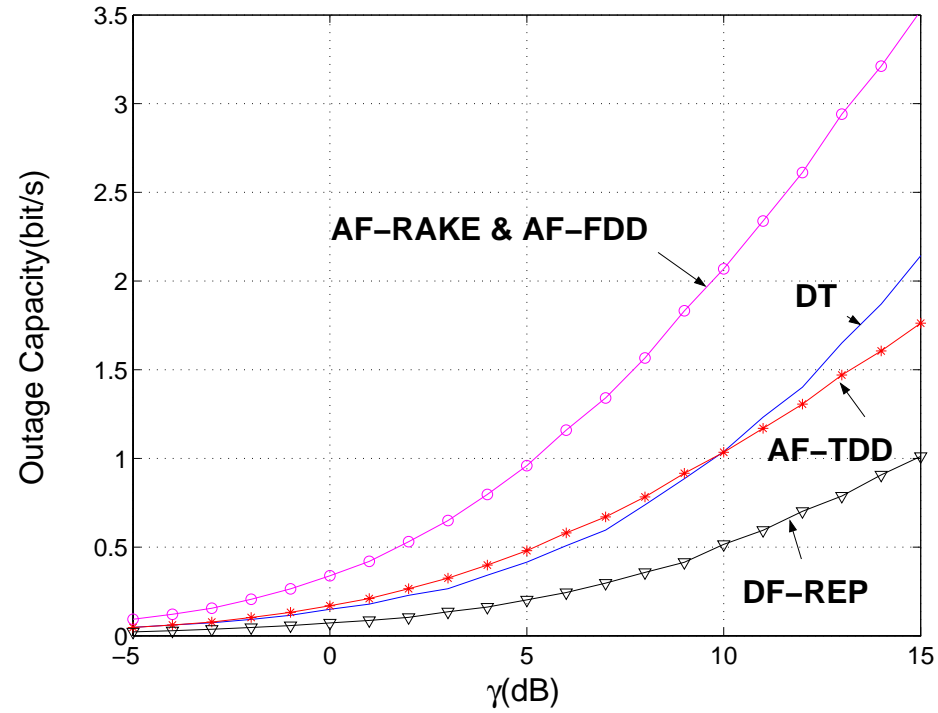
# Introduction to Cooperative Relay

Cooperative strategy	Channel Usage	Time penalty	Theoretical capacity
<b>Direct Transmission (DT)</b> 	1	1	$W \log(1 + \gamma  h_{21} ^2)$
<b>Amplified and Forward – RAKE (AF-RAKE)</b> 	1	1	$W \log(1 + \gamma  h_{21} ^2 + f(\gamma  h_{31} ^2, \gamma  h_{23} ^2))$
<b>Amplified and Forward – FDD (AF-FDD)</b> 	2	1	$W \log(1 + \gamma  h_{21} ^2 + f(\gamma  h_{31} ^2, \gamma  h_{23} ^2))$
<b>Amplified and Forward – TDD (AF-TDD)</b> 	1	2	$\frac{W}{2} \log(1 + \gamma  h_{21} ^2 + f(\gamma  h_{31} ^2, \gamma  h_{23} ^2))$
<b>Decode and Forward – REP (DF-REP)</b> 	1	2	$\frac{w}{2} \min \left\{ \begin{array}{l} \log(1 + \gamma  h_{31} ^2), \\ \log(1 + \gamma  h_{21} ^2 + \gamma  h_{23} ^2) \end{array} \right\}$

# Single Link Performance

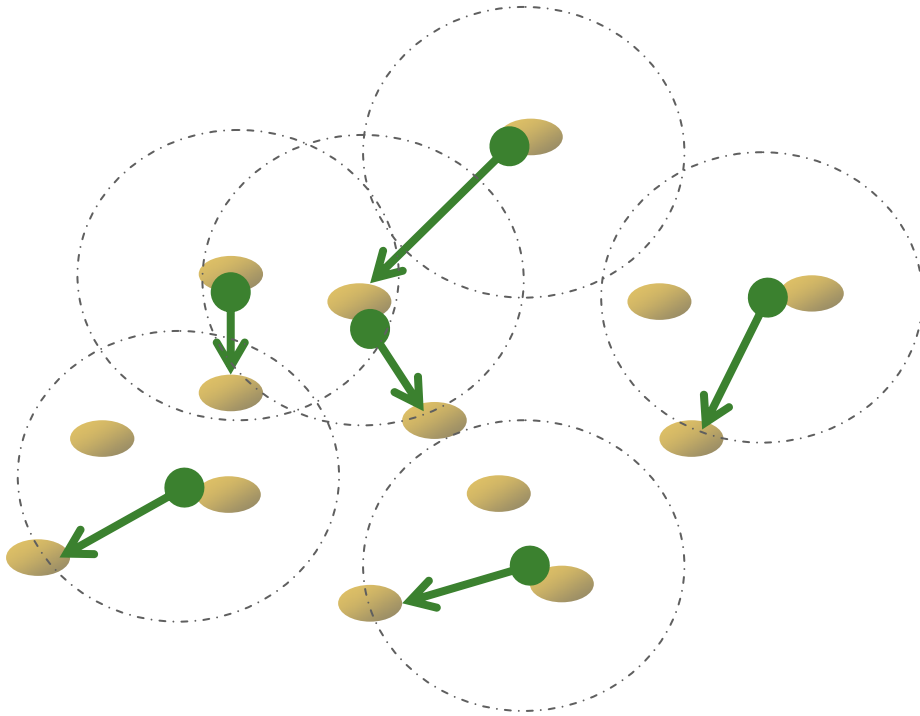


Ergodic Capacity

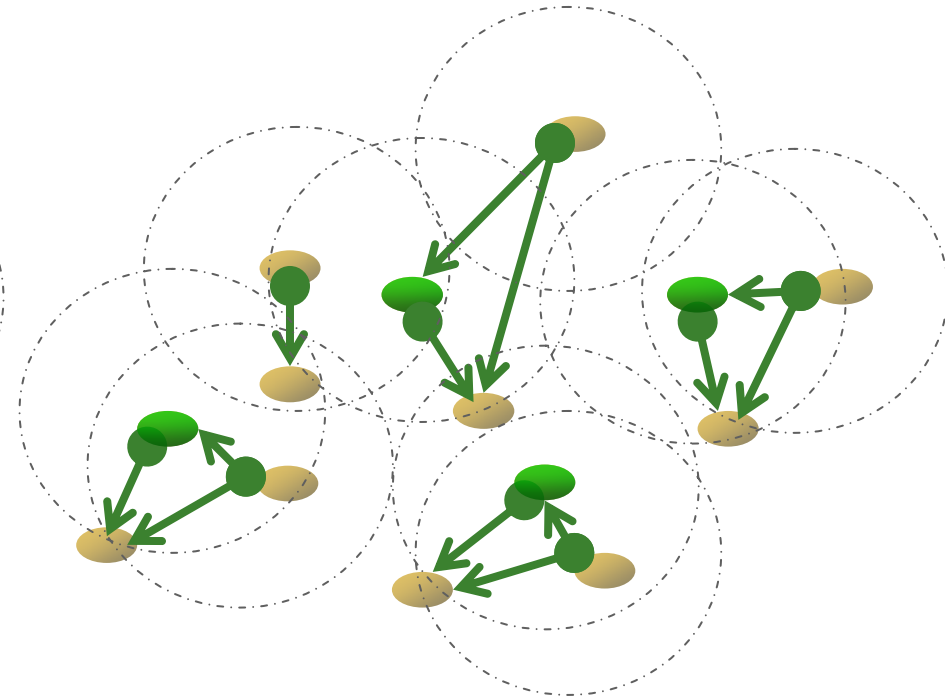


Outage Capacity (10%)

# Interference Does Matter!



***Direct Link in a network***



***Cooperative Relay in a network***

# Relay Interference Management

## *Relay Selection*

*Src sends out solicitation request,  
Neighbors respond with self-condition  
Select the relay with*

- Minimum Distance*
- Minimum Load*
- Minimum Interference*

## *Decide Strategy*

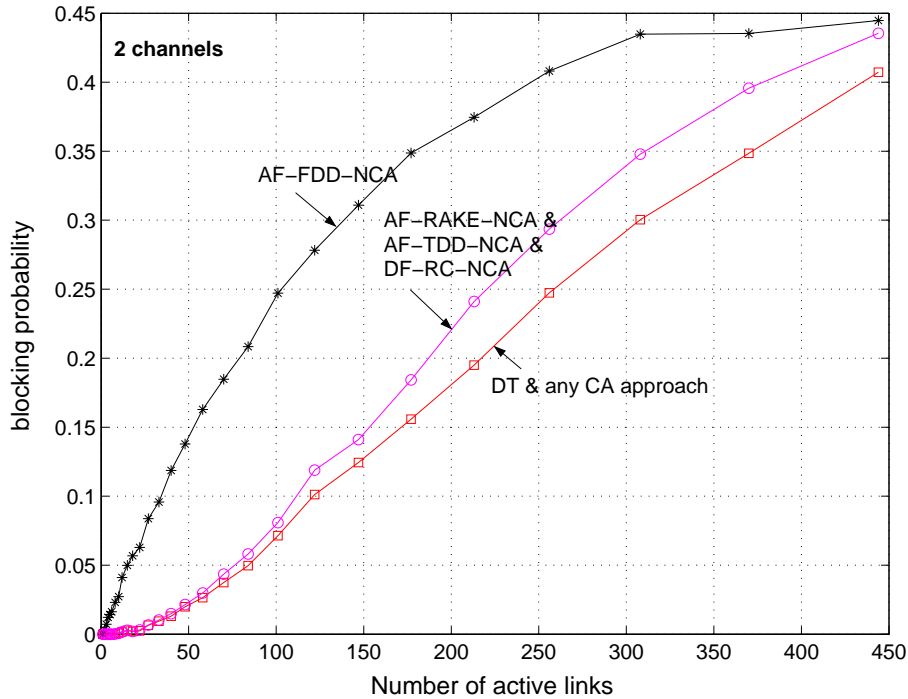
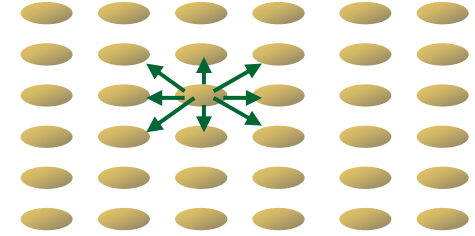
*Depend on hardware (full/half duplex)  
& Resource condition*

## *Resource Contention*

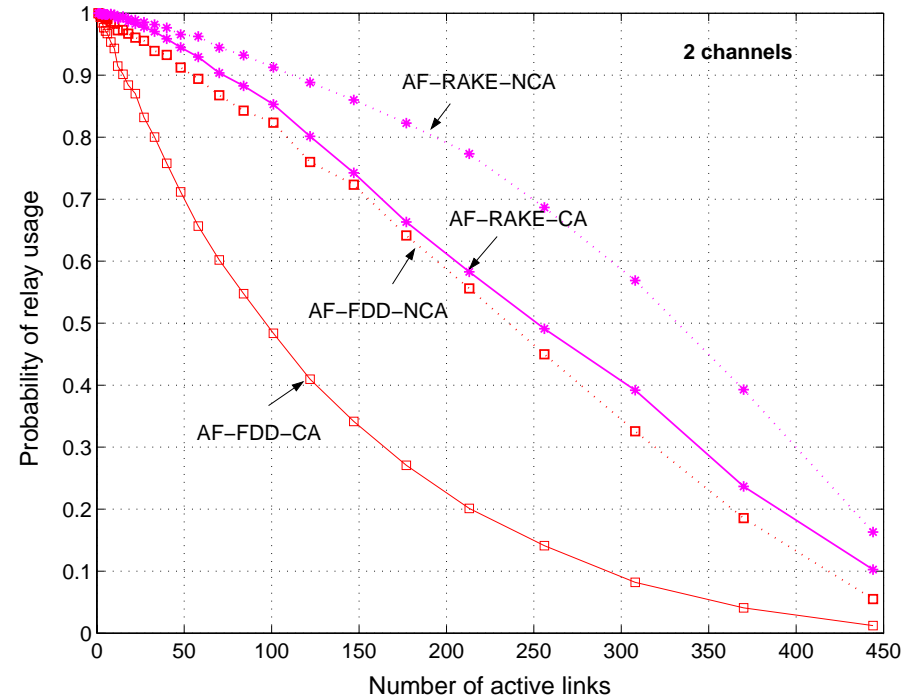
*Compete for Channels for both direct &  
relay links*

- Cooperative: direct first, relay later*
- Noncooperative: direct+relay*

# System Statistics



*Blocking Probability*

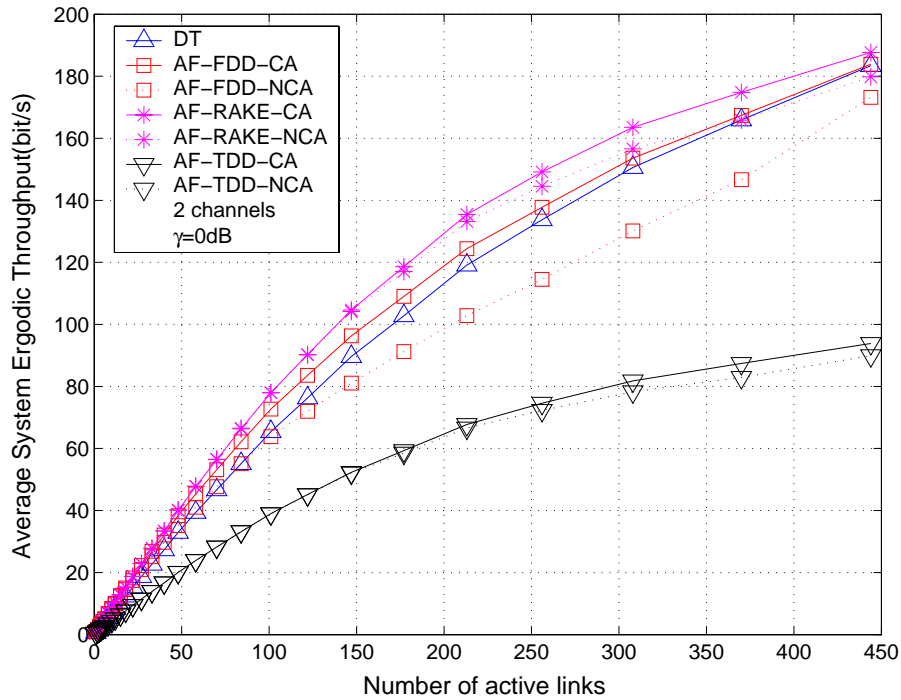


*Relay Usage*

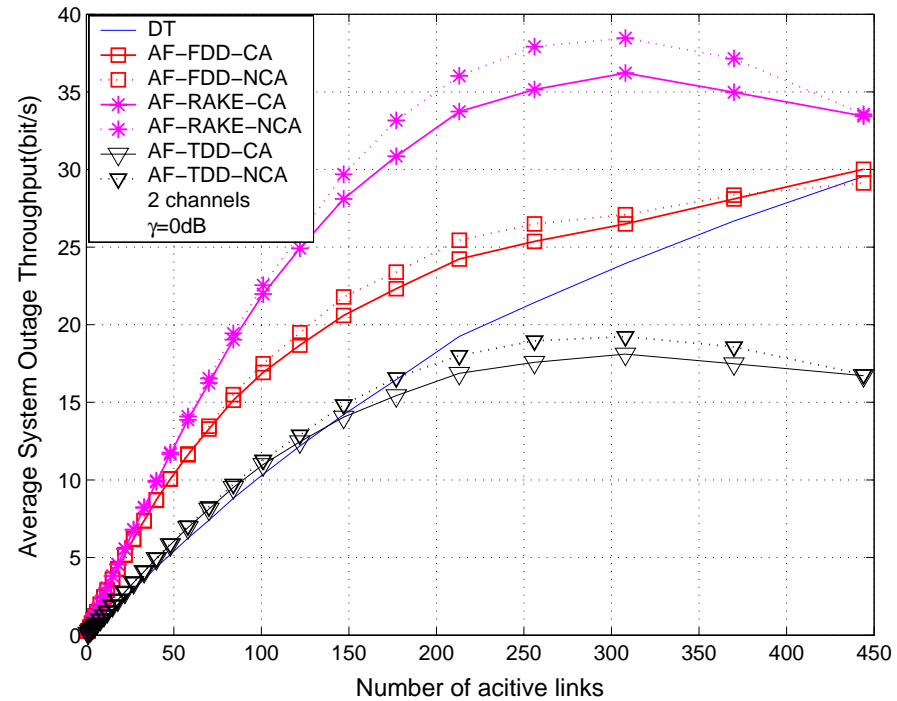
Selfish relay usage leads to higher blocking

Selfish relay leads to higher probability of relay usage

# Average Link Capacity



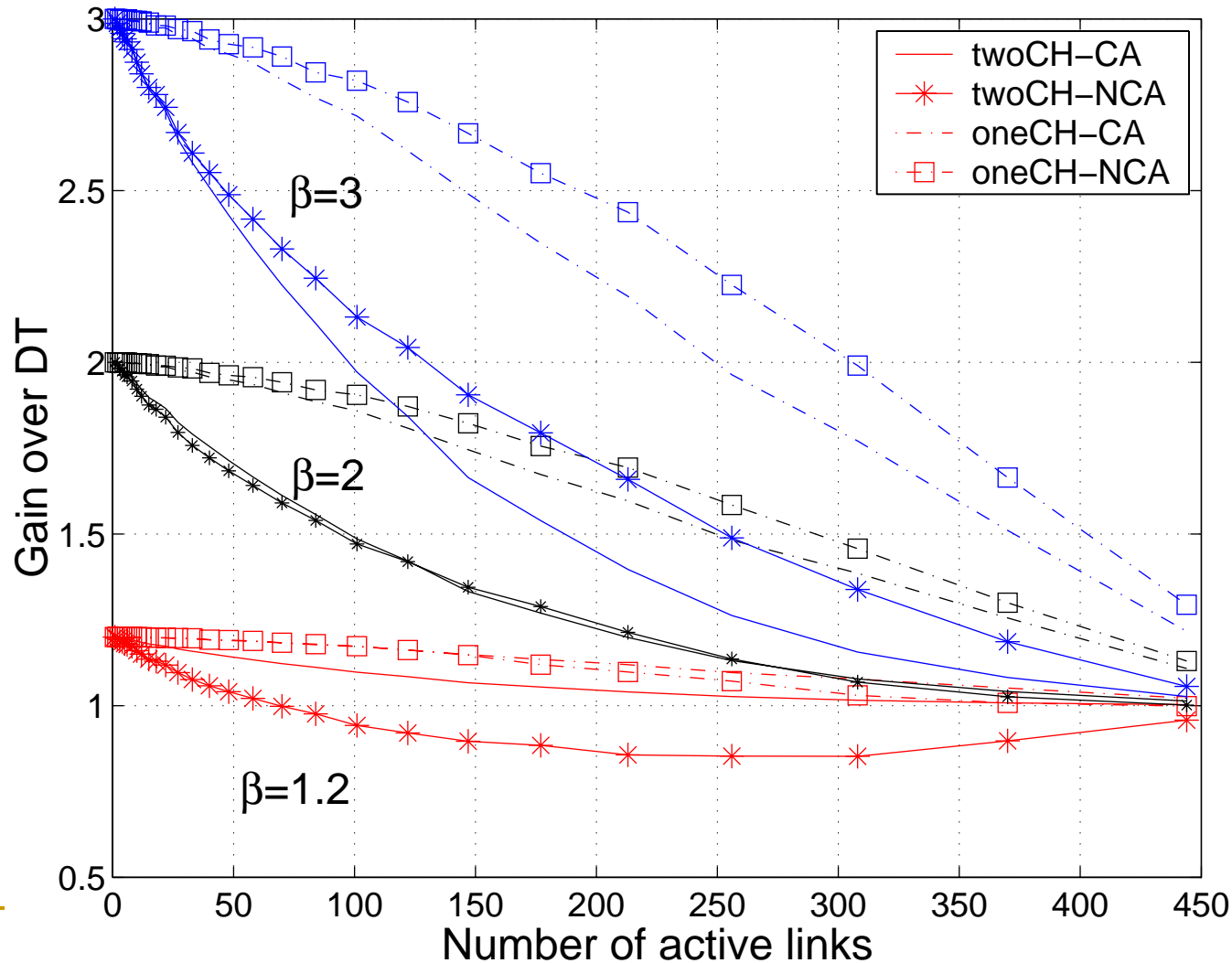
Ergodic Capacity



Outage Capacity (10%)



# Impact of Cooperative Link Gain



---

# Conclusion and on-going work

- Cooperative Relay in an Interference Limited Environment
  - Careless/selfish usage of cooperative relays yields higher connection blocking probabilities
  - Interference Management
  - Extensions
    - Random topology
    - Theoretical analysis
-