Comments on Throughput Comparison for 16m Relay Frame Structure Options

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Venue:
SDD, in response to Call for Comments/Contributions (IEEE 802.16 #57 Kobe, Japan)
Re:
IEEE 802.16m-08/033: Call for Contributions and Comments on Project 802.16m System Description Document (SDD), Target topic: “SDD Session 56 Cleanup, Call for PHY details”.
Base Contribution:
C80216m-08_1058r1.pdf (Intel)
Purpose:
For discussion about the above mentioned contribution on throughput comparison of Relay Frame Structure options in 16m SDD
Notice:

Release:

Patent Policy:

Comments on Throughput Comparison for 16m Relay Frame Structure Options

LG Electronics

Outline

- Throughput, in terms of what?
  - A single-hop network and a multi-hop network have different meaning of “throughput” in terms of the actual average throughput the users can experience.
  - A tree network and a mesh network have different level of asymmetry between UL and DL.
  - In tree networks, each node (e.g., RS) still has the traffic asymmetry that the two end nodes (e.g., BS and MS) have.
    - As far as the asymmetry comes, the throughput in nature has an important bottleneck, which needs to be considered to examine the throughput performance of a given FS.
  - Related contribution(s): C80216m-08_1058r1.pdf (Intel)

Adaptation Capability for Traffic Asymmetry (1/2)

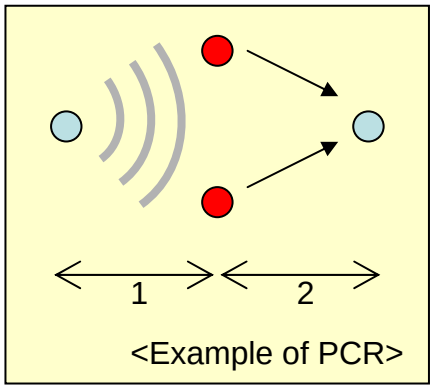
- Asymmetry b/w Traffic Volume Demands in UL and DL
- Why is “Adaptation Capability” important?
  - Traffic asymmetry between UL and DL is an inherent characteristic of a tree network (whether multihop or not).
  - With a limited number of subframes in a single radio frame for DL-A, DL-R, UL-A, and UL-R zones, the actually experienced level of throughput is completely upper-bounded by the one (either UL or DL) that is saturated first.
    - This is the same problem even when both UL and DL are saturated/overloaded because the utility (value of resource utilization) still falls into a non-optimal situation.

Adaptation Capability for Traffic Asymmetry (2/2)

- Comparison
  - Option 1:
    - No substantial adaptation capability but changing the number of subframes for each zone
  - Option 2:
    - Better adaptation capability through bidirectional zones

Capability of Cooperative Diversity (1/4)

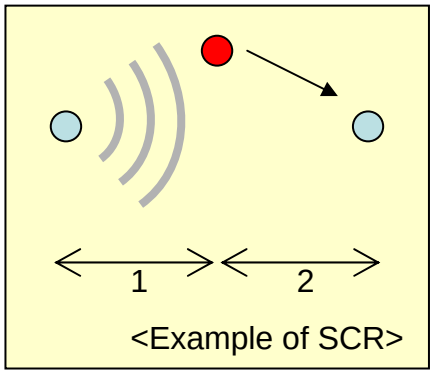
- Parallel Cooperative Relaying (PCR)
  - min. # (required) RS's = 2
  - What if # RS's <2, no PCR gain
    - In Option 1, no SCR gain, either
  - Probability perspective:
    - Pr{# RS's >= 2} = 1 - Pr{# RS's =1} - Pr{# RS's =0}
    - Example (Poisson): $\Pr\{PCR\} = 1 - \exp(-\lambda) - \lambda \exp(-\lambda)$



<Example of PCR>

- Single Cooperative Relaying (SCR)
  - min. # (required) RS's = 1
  - What if # RS's <2, still SCR gain (if >= 1)
  - Probability perspective:
    - Pr{# RS's >= 1} = 1 - Pr{# RS's =0}
    - Example (Poisson): $\Pr\{SCR\} = 1 - \exp(-\lambda)$

$$= \Pr\{PCR\} + \lambda \exp(-\lambda)$$



<Example of SCR>

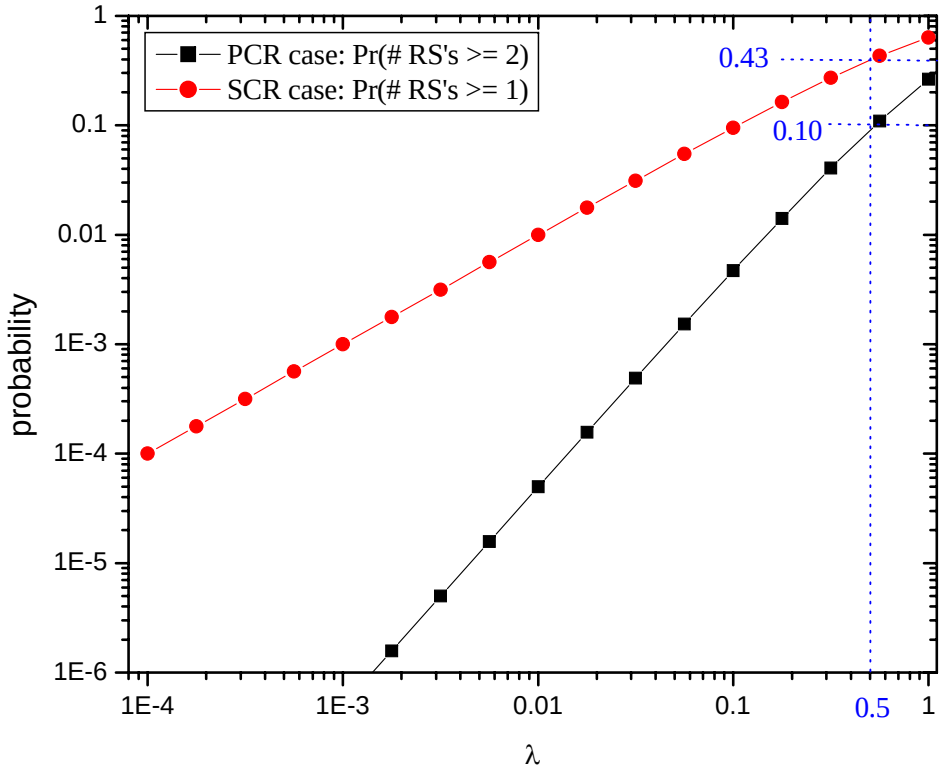
Capability of Cooperative Diversity (2/4)

- Comparison of Probability
  - Probability for having min. # required RS(s): for PCR (>1), for SCR (>0)
  - Option 1: PCR gain with low probability, no SCR gain at all times
    - The even-numbered are transmitting while the odd-numbered are receiving: grandparent cannot hear grandchild (both in Tx)
  - Option 2: PCR gain with low probability, SCR gains with higher probability

# RS's that can hear from MS	Option 1	Option 2
0	No PCR gain No SCR gain	No PCR gain No SCR gain
1	No PCR gain No SCR gain	No PCR gain with SCR gain
2 or more	possible PCR gain No SCR gain	possible PCR gain with SCR gain

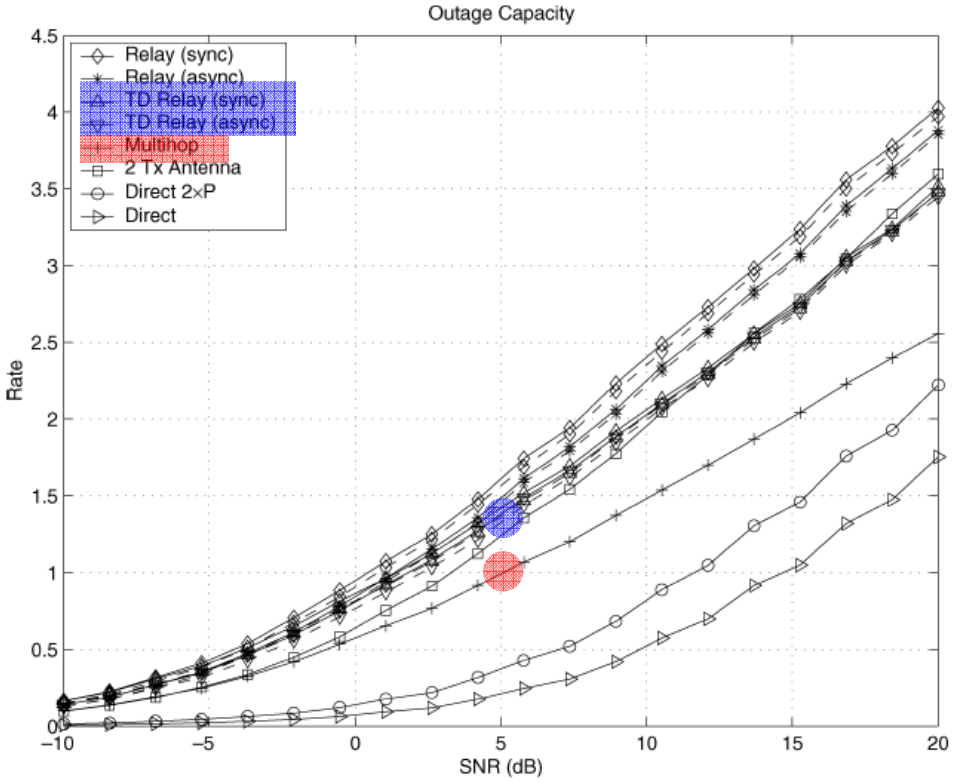
Capability of Cooperative Diversity (3/4)

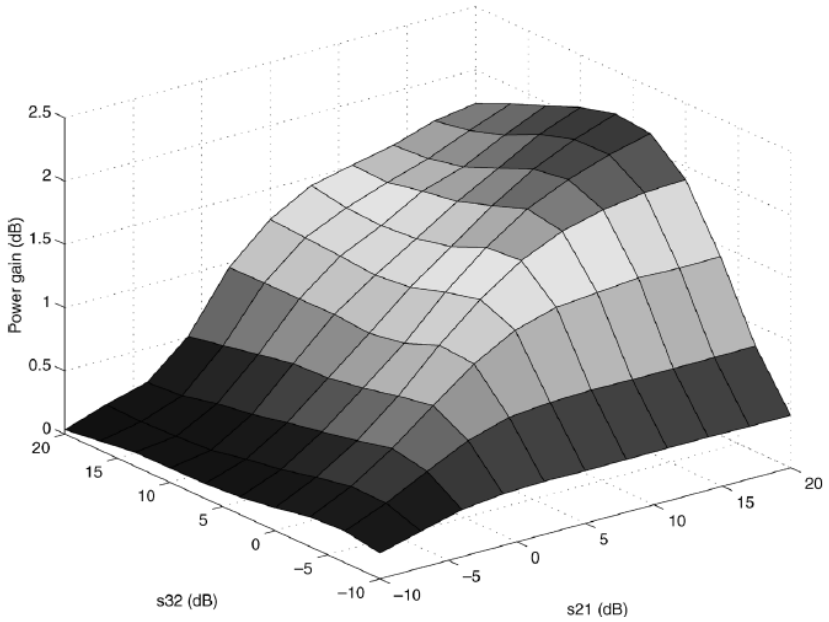
- Toy example for Probability Comparison: PCR and SCR cases
  - Setup:
    - BS coverage radius: 2km; RS coverage radius: 0.5km
    - # RS's in BS coverage area (near cell boundary): 8
    - Binomial approximation (N=8, p=1/16); Poisson approximation (λ=N*p=1/2)
  - Result:



Capability of Cooperative Diversity (4/4)

- How much is SCR gain?
  - 30% in rate; 1.2dB in power





<Source: "Capacity Bounds and Power Allocation for Wireless Relay Channels," *IEEE Trans Info. Theory*, Vol. 51, No. 6, June 2005>

Comparison: Different Types of Cooperative Relaying (CR) in Option 1 and Option 2

- PCR: (not always possible for both UL and DL in both Options)
  - (to achieve PCR gain, two parallel RS's must be able to decode)
  - if parent schedules, it requires significant control signaling overhead b/w two parallel RS's for synchronized resource assignment (in both UL and DL);
  - if grandparent schedules, no extra overhead
- DL SCR: (possible in both Options but requires more control overhead than UL SCR)
  - if grandparent schedules, the MS must know where grandparent and parent will send (extra overhead: need to know where to hear from grandparent)
  - if parent schedules, the MS must know where grandparent and parent will send (extra overhead: where to hear from grandparent)
- UL SCR: (not possible in Option 1)
  - when parent signals resource assignment to MS, grandparent can also hear without additional signaling overhead
- Summary:
  - For UL CR, only Option 2 with SCR is feasible