

# A New Decode-Rotate-and-Forward Strategy for Cooperative Relay Networks

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Laboratoire IETR-INSA

# Outline

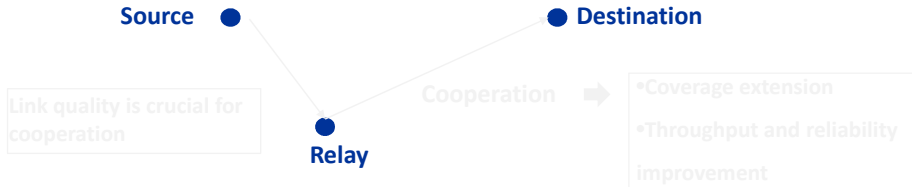
- 1 Motivation
- 2 Proposed Decode-Rotate-and-Forward Scheme
- 3 Numerical Results
- 4 Conclusion

## Cooperative communications

- Wireless networks: From point-to-point to **Cooperative Communications**: Several nodes cooperate to transmit information to the destination
- In the **broadcasting** context, cooperative relaying techniques can be exploited for coverage extension and/or power saving purposes

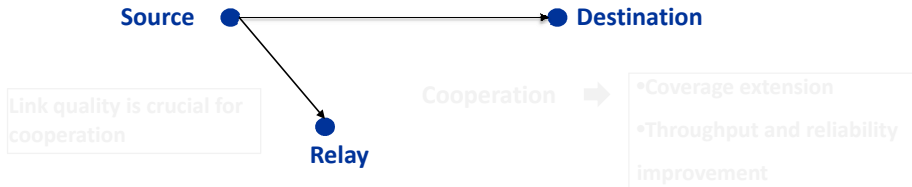
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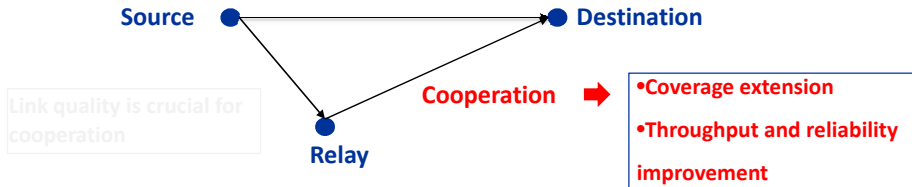
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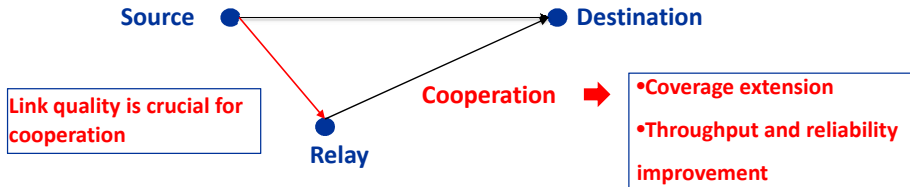
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## Cooperative protocols at the relay

- Amplify-and-Forward (AF): the relay simply amplifies the received signal
- Decode-and-Forward (DF): the relay decodes the received signals and generates an extra redundancy
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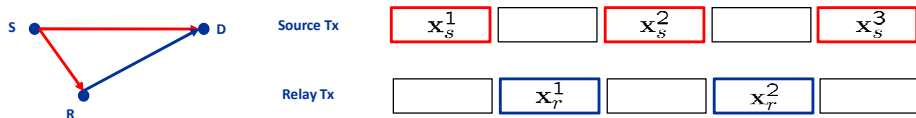
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- Proposed distributed coding schemes in the literature:

-Transmission time divided into two slots



Non optimal solution in terms of spectral efficiency!

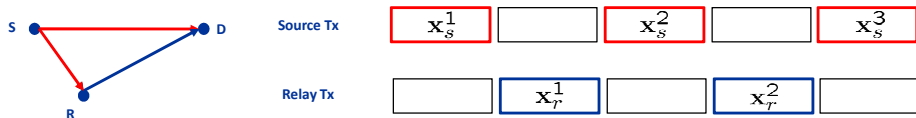
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Performance improvement in terms of spectral efficiency while maintaining a robust source-to-relay link

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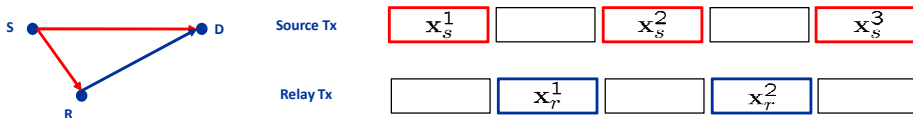
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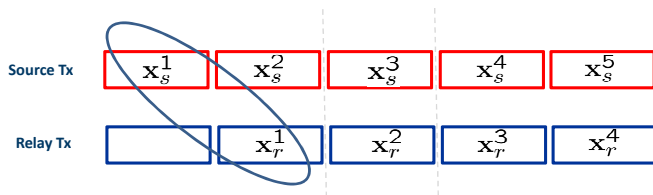
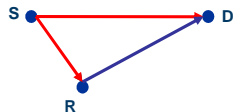
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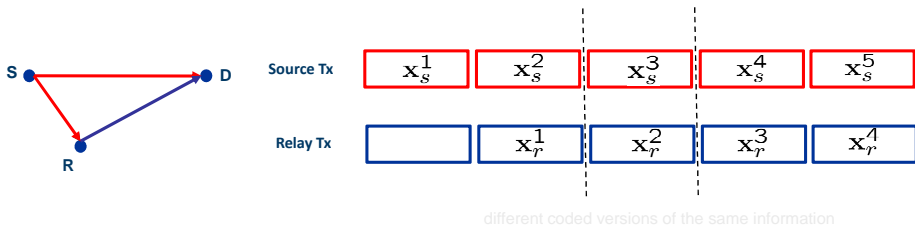
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different coded versions of the same information

# Simultaneous Transmission

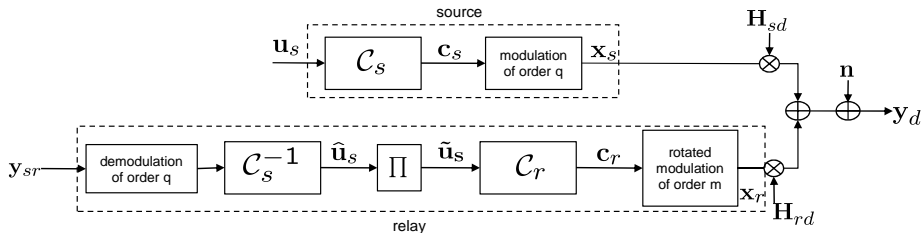
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**How to separate the signals received at the destination from the source and the relay?**



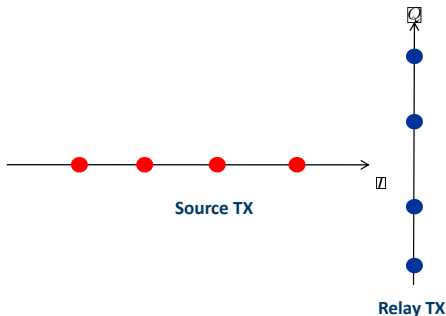
# Decode-Rotate-and-Forward Strategy



- At source  $S$ , the information sequence  $\mathbf{u}_s$  is encoded by encoder  $\mathcal{C}_S$  of rate  $R_S$  into codeword  $\mathbf{c}_s$
- Codeword  $\mathbf{c}_s$  is then modulated into  $\mathbf{x}_s$  using a modulation of order  $q$
- The relay  $R$  decodes  $\mathbf{c}_s$  and generates extra redundancy  $\mathbf{c}_r$
- Codeword  $\mathbf{c}_r$  is then modulated into  $\mathbf{x}_r$  using a modulation of order  $m$  rotated by an angle  $\varphi$

# Distributed Constellation

- Transmission over orthogonal I and Q

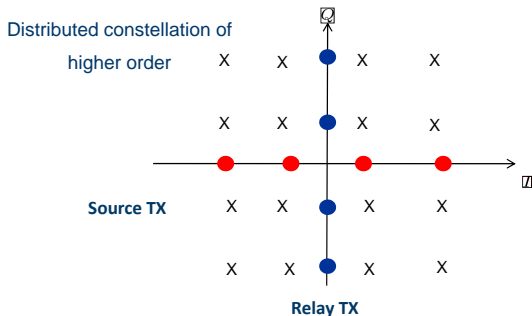


## Key idea

- If we consider a constellation of order  $q$  at the source and a constellation of order  $m$  at the relay, the equivalent constellation at the receiver side must be of order  $q + m$
- Each point of the  $2^{q+m}$  points of the new constellation is associated to a unique pair of the source and the relay symbols

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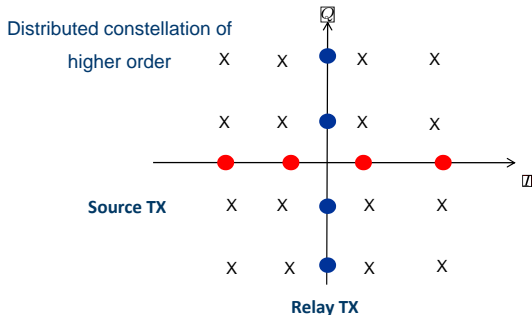


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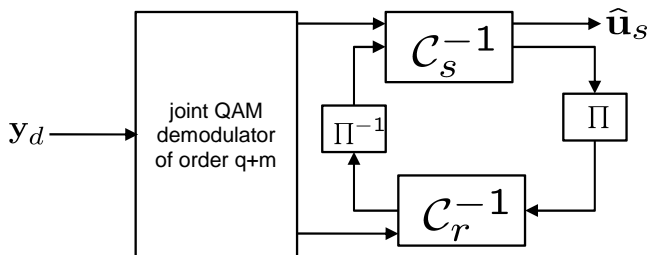


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# Joint Demodulation and Decoding at the Destination

- At destination  $D$ , a **higher order** demodulator is used to jointly demodulate the received sequence  $\mathbf{y}_d$



- Decoding of the source information is performed in the classic way of a distributed turbo code

## Reference systems

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# Numerical Results (I)

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Modulation symbols                      Symbols of higher order modulation

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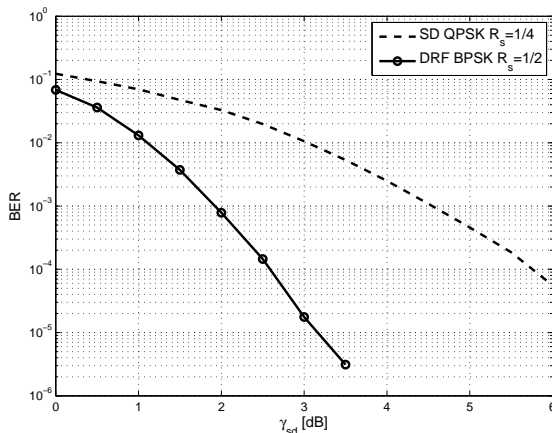
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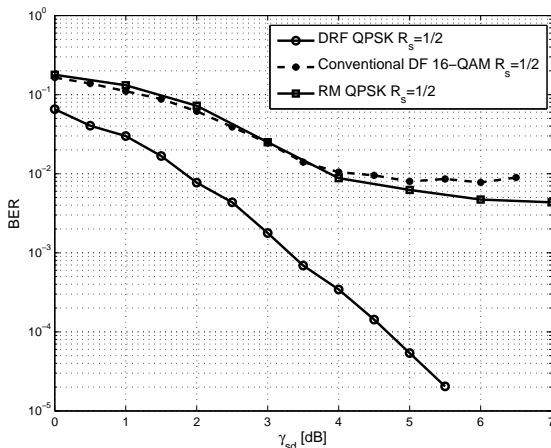
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# Numerical Results (II)



- $k_{BS} = 128$  bits  $R_s = 1/2$ , 10 iterations
- AWGN channels,  $\gamma_{rd} = \gamma_{sd}$ ,  $\gamma_{sr} \gg$
- BPSK modulation at the source and a rotated BPSK of angle  $\varphi = 90^\circ$  at the relay (DRF)

# Numerical Results (III)



- $k_{BS} = 128$  bits  $R_s = 1/2$ , 10 iterations
- AWGN channels,  $\gamma_{rd} = \gamma_{sd}$ ,  $\gamma_{sr} = 8$  dB
- QPSK modulation at the source and a rotated QPSK of angle  $\varphi = 30^\circ$  at the relay (DRF)

# Conclusion

- A new relaying strategy, **decode-rotate-and-forward**, for wireless relay networks is proposed
- Significant gain is achieved compared to the non-cooperation scheme
- The proposed scheme allows the channel resource to be efficiently exploited and higher spectral efficiency to be achieved compared to schemes where the transmission time is shared between the source and the relay
- The proposed scheme is flexible in terms of modulation order choice used at the source and the relay

Thank you!!  
Questions?