Full-Duplex Relaying in MIMO-OFDM Frequency-Selective Channels with Optimal Adaptive Filtering

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creating and sharing knowledge for telecommunications

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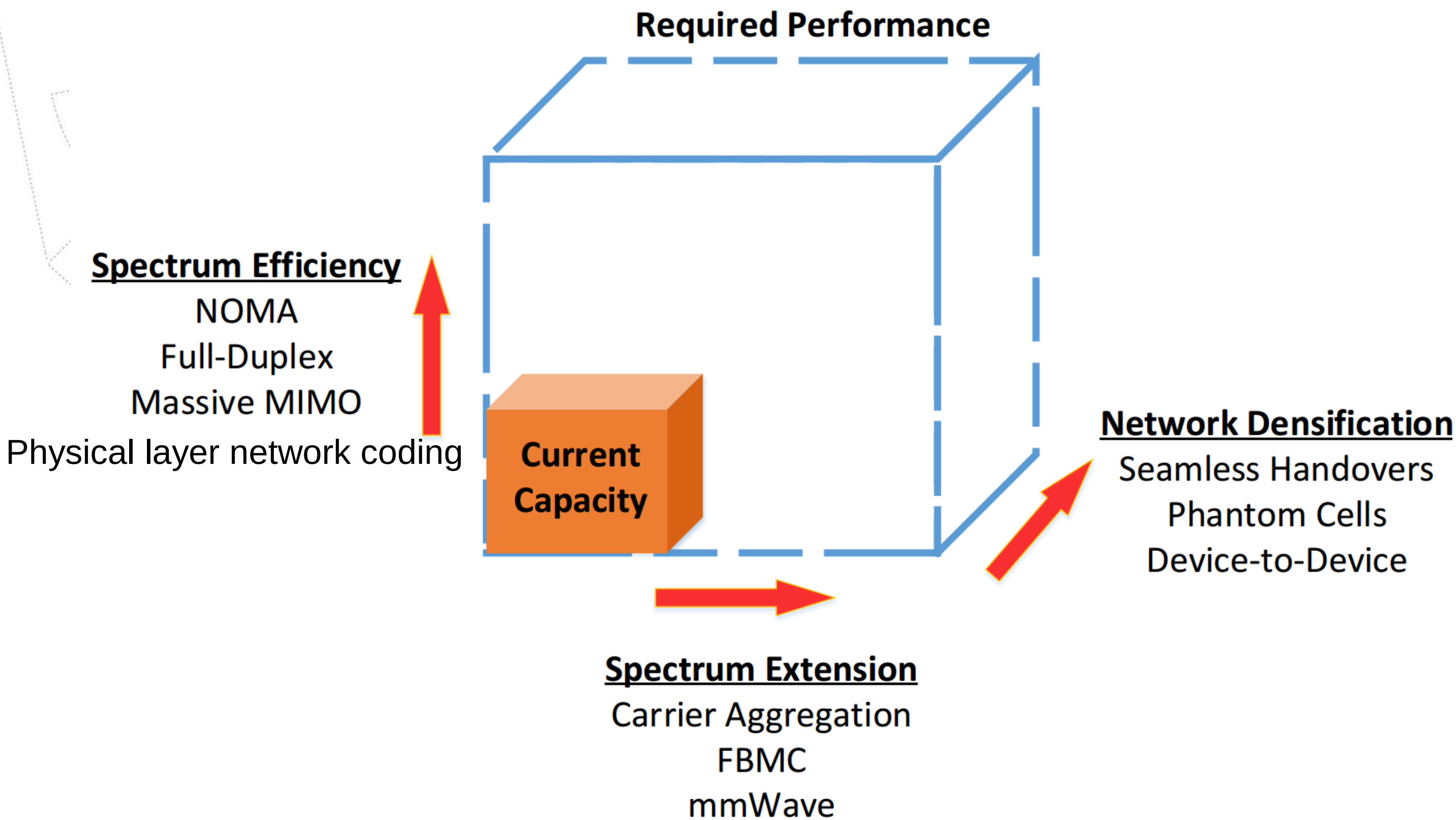
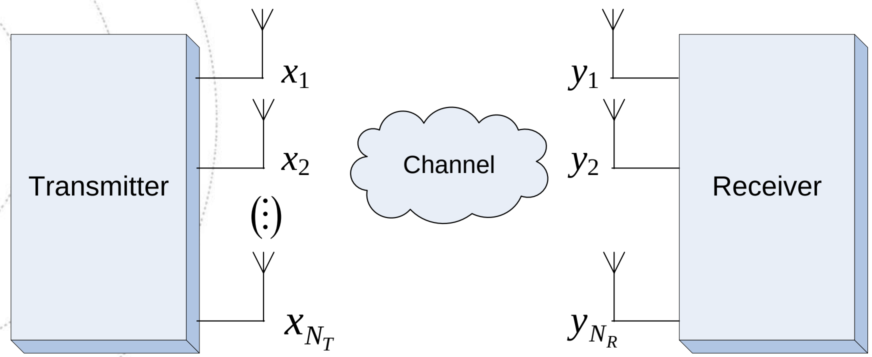
How to offer more?



Multiple-input multiple-output (MIMO) detection



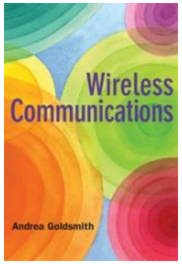
$$\begin{bmatrix} \mathbf{y}_1 \\ \mathbf{y}_2 \\ \vdots \\ \mathbf{y}_{N_R} \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} & \cdots & h_{1N_T} \\ h_{21} & h_{22} & \cdots & h_{2N_T} \\ \vdots & \vdots & \ddots & \vdots \\ h_{N_R 1} & h_{N_R 2} & \cdots & h_{N_R N_T} \end{bmatrix} \cdot \begin{bmatrix} \mathbf{x}_1 \\ \mathbf{x}_2 \\ \vdots \\ \mathbf{x}_{N_T} \end{bmatrix} + \begin{bmatrix} \mathbf{n}_1 \\ \mathbf{n}_2 \\ \vdots \\ \mathbf{n}_{N_R} \end{bmatrix}$$

$$\mathbf{y} = \mathbf{H}\mathbf{x} + \mathbf{n}$$

$$\hat{\mathbf{x}}_{ML} = \min_{\mathbf{x}} \left\{ \left\| \mathbf{y} - \mathbf{H}\mathbf{x} \right\|^2 \right\}$$

Recent state-of-the-art in radio science

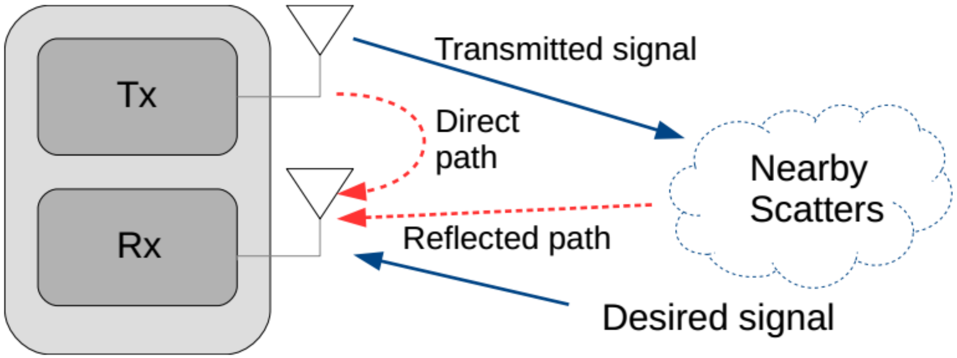
"It is generally not possible for radios to receive and transmit on the same frequency band because of the interference that results."

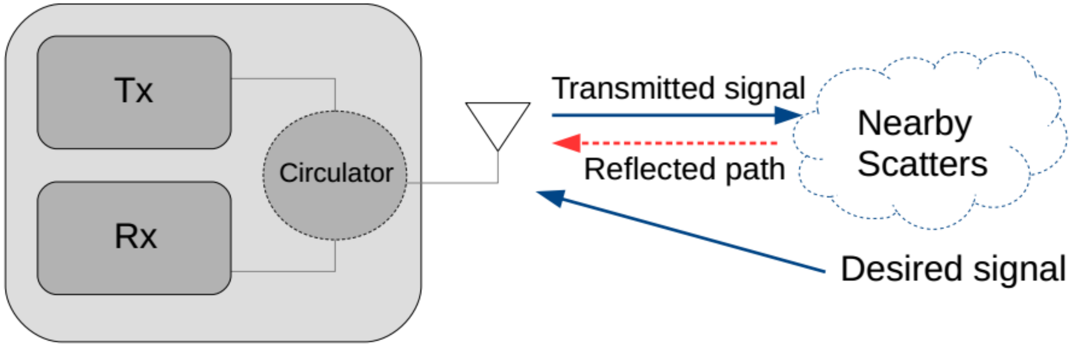


Andrea Goldsmith,

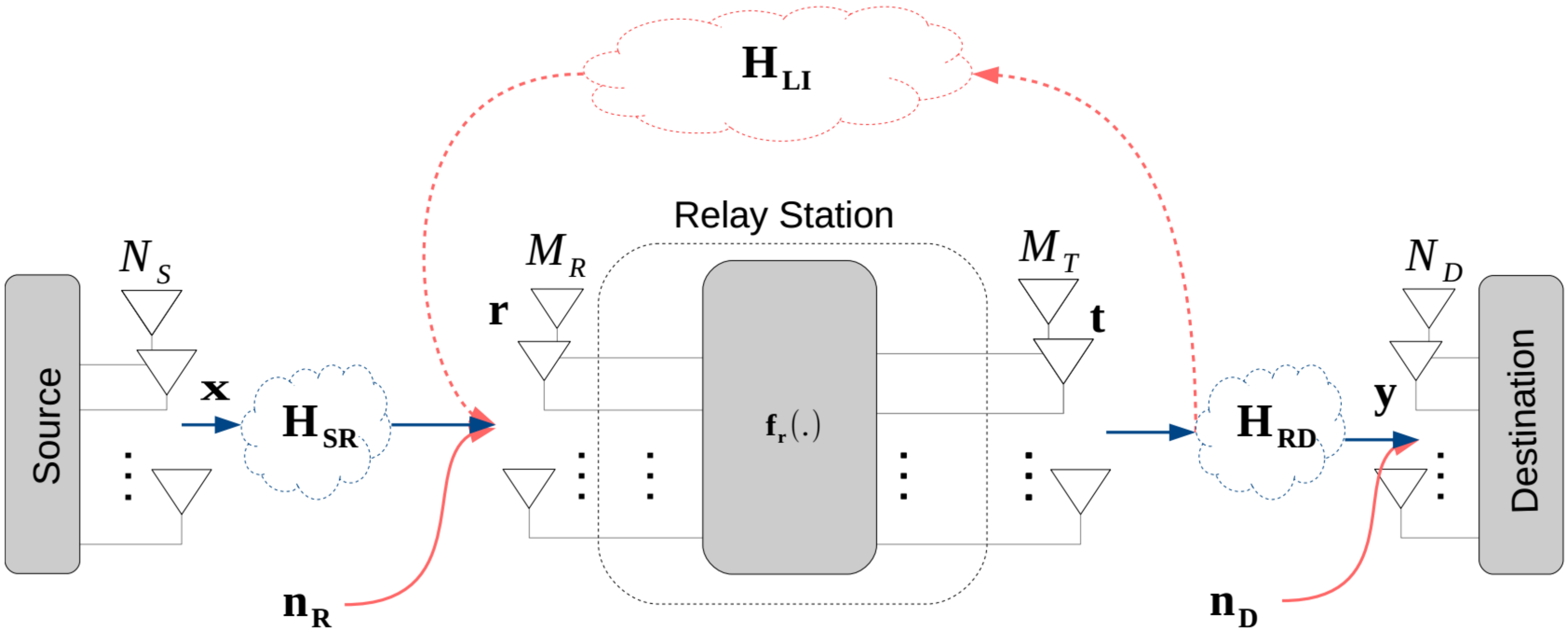
In *Wireless Communications*, Cambridge University Press, p. 454, 2003

Two possible antenna setups

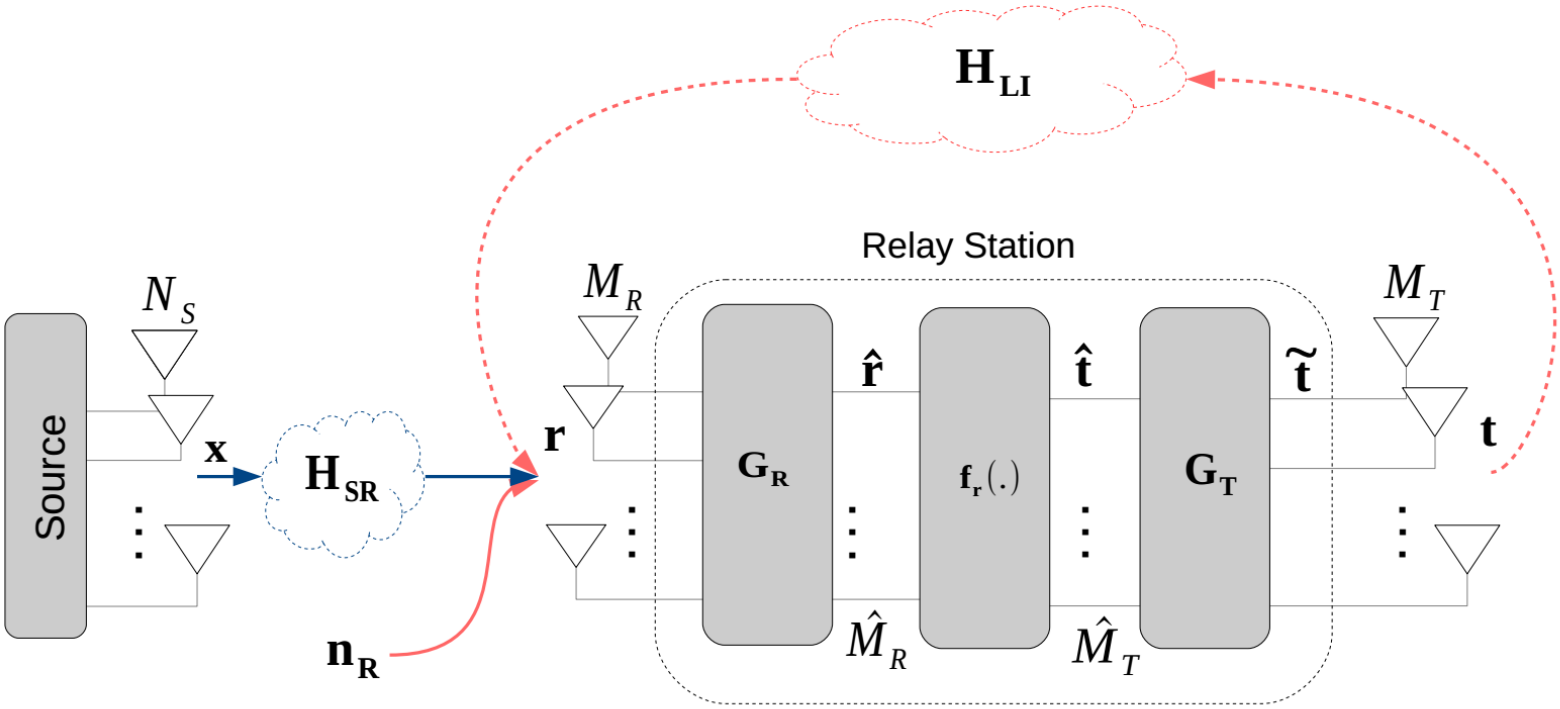




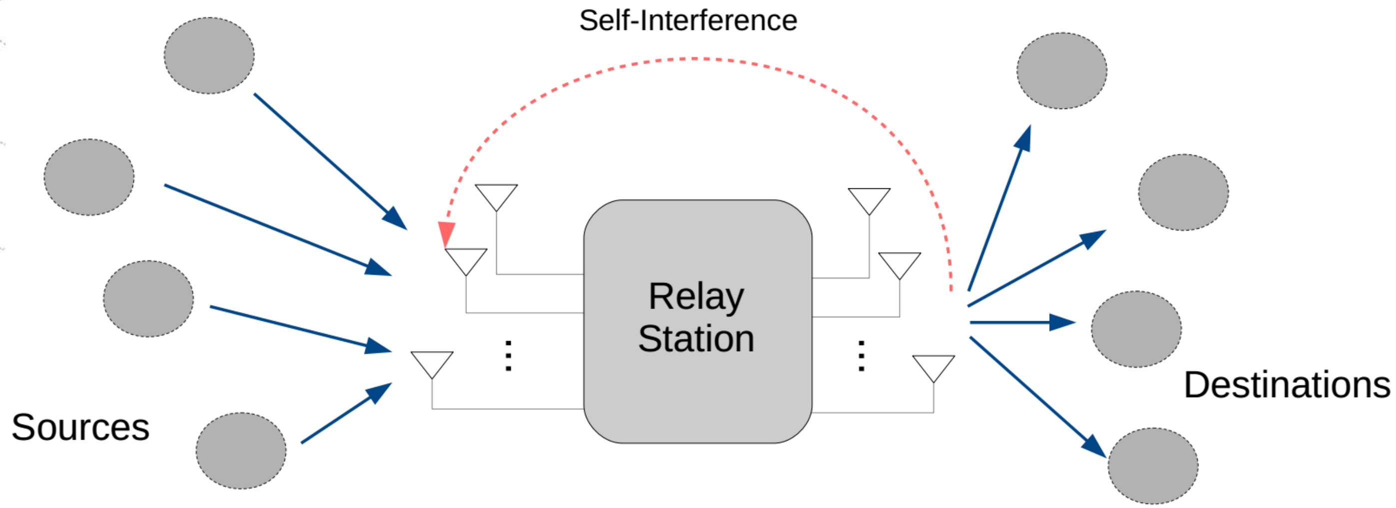
System model for in-band full-duplex with a relay station



Linear filter design for time-domain cancellation: receive filters and transmit filters

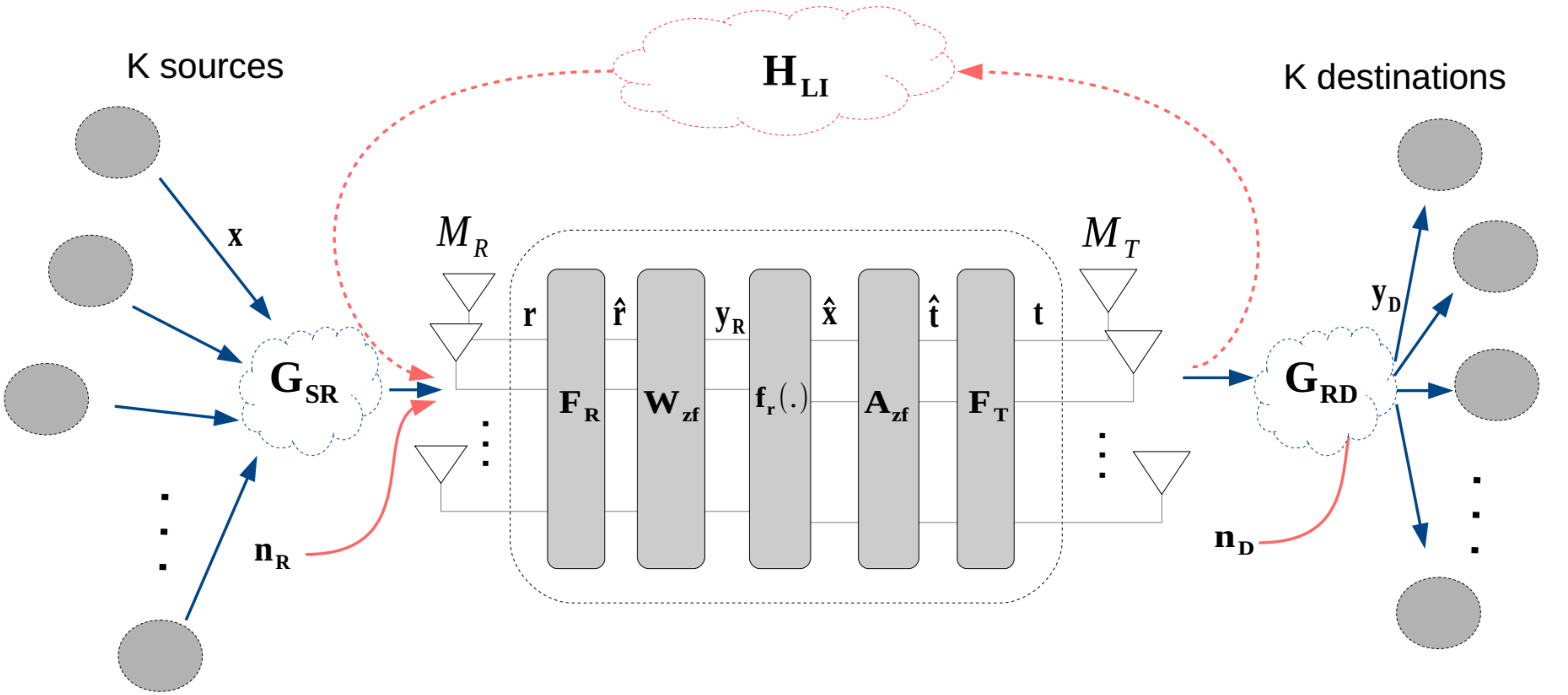


Alternative application: multi-pairs with a full-duplex relay (1/2)



See e.g., [J. S. Lemos, F. Rosário, F. A. Monteiro, J. Xavier, A. J. Rodrigues, ***"Massive MIMO Full-Duplex Relaying with Optimal Power Allocation for Independent Multipairs"***, in Proceedings of **SPAWC 2015** , Stockholm, Sweden, June 2015.]

Alternative application: multi-pairs with a full-duplex relay (2/2)



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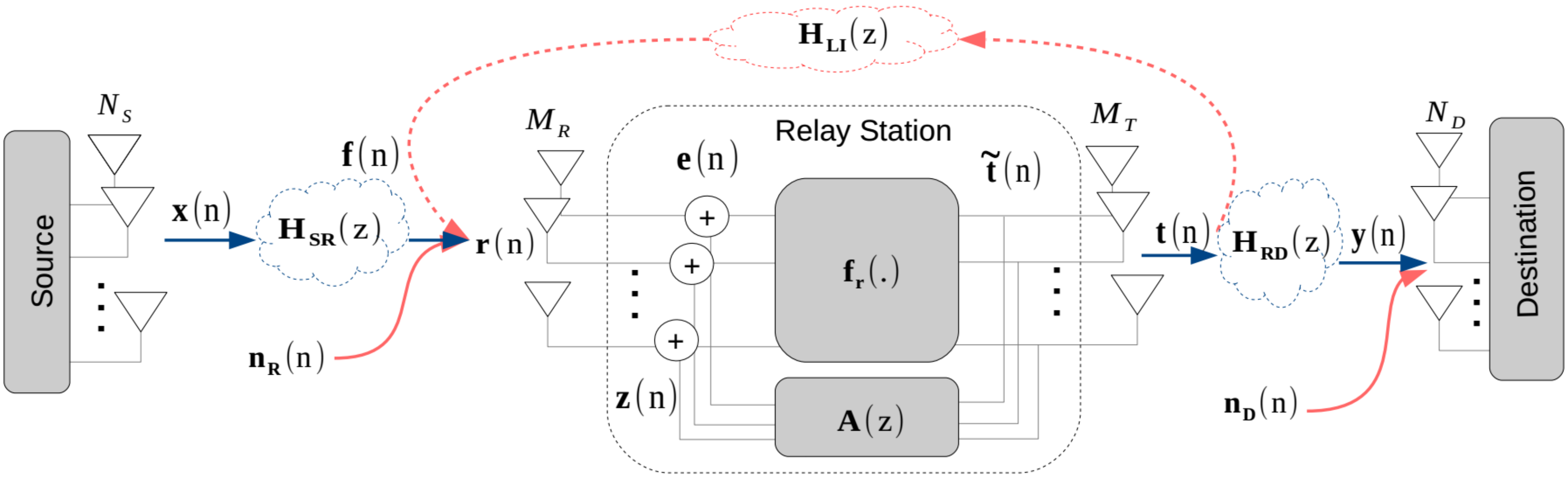
Proposal: feedback filtering for interference cancellation



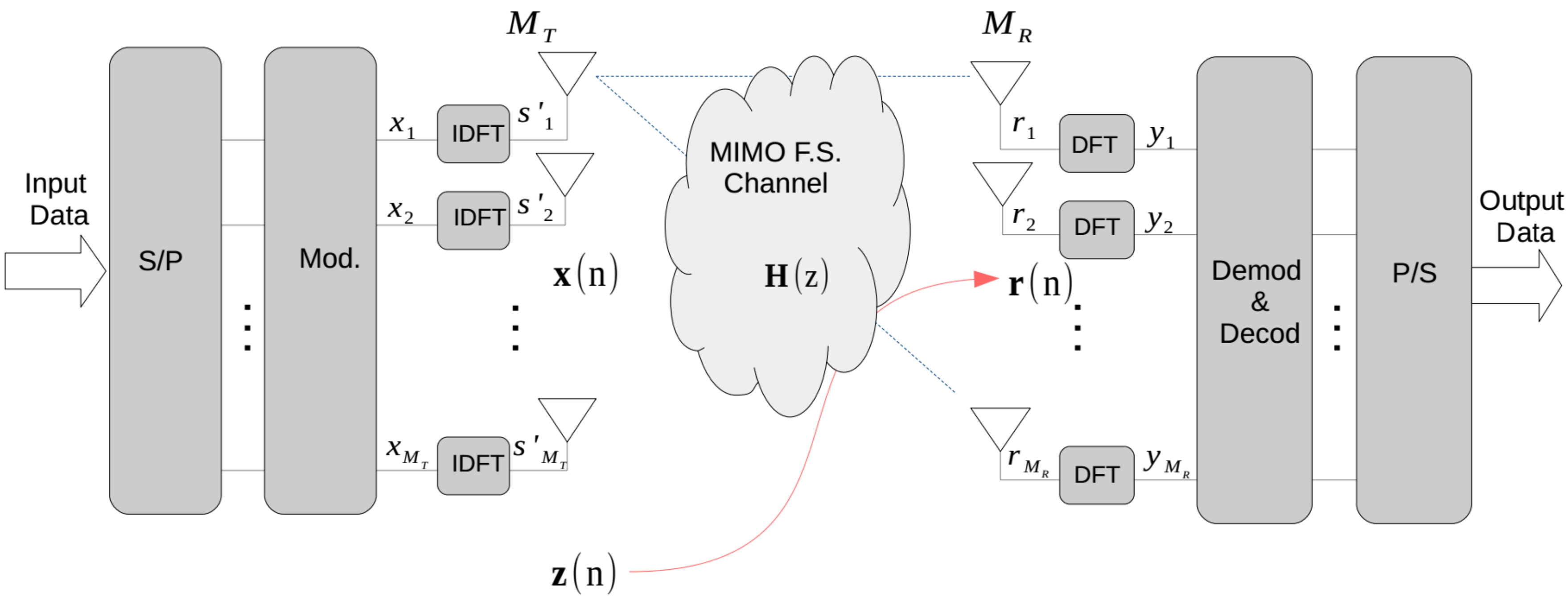
$$\mathbf{q}(n) = \mathbf{H_{SR}}(z)\mathbf{x}(n) + \mathbf{H_{LI}}(z)\mathbf{t}(n) + \mathbf{n_R}(n),$$
$$\mathbf{y}(n) = \mathbf{H_{RD}}(z)\mathbf{t}(n) + \mathbf{n_D}(n),$$

<u>Minimum squared error</u>

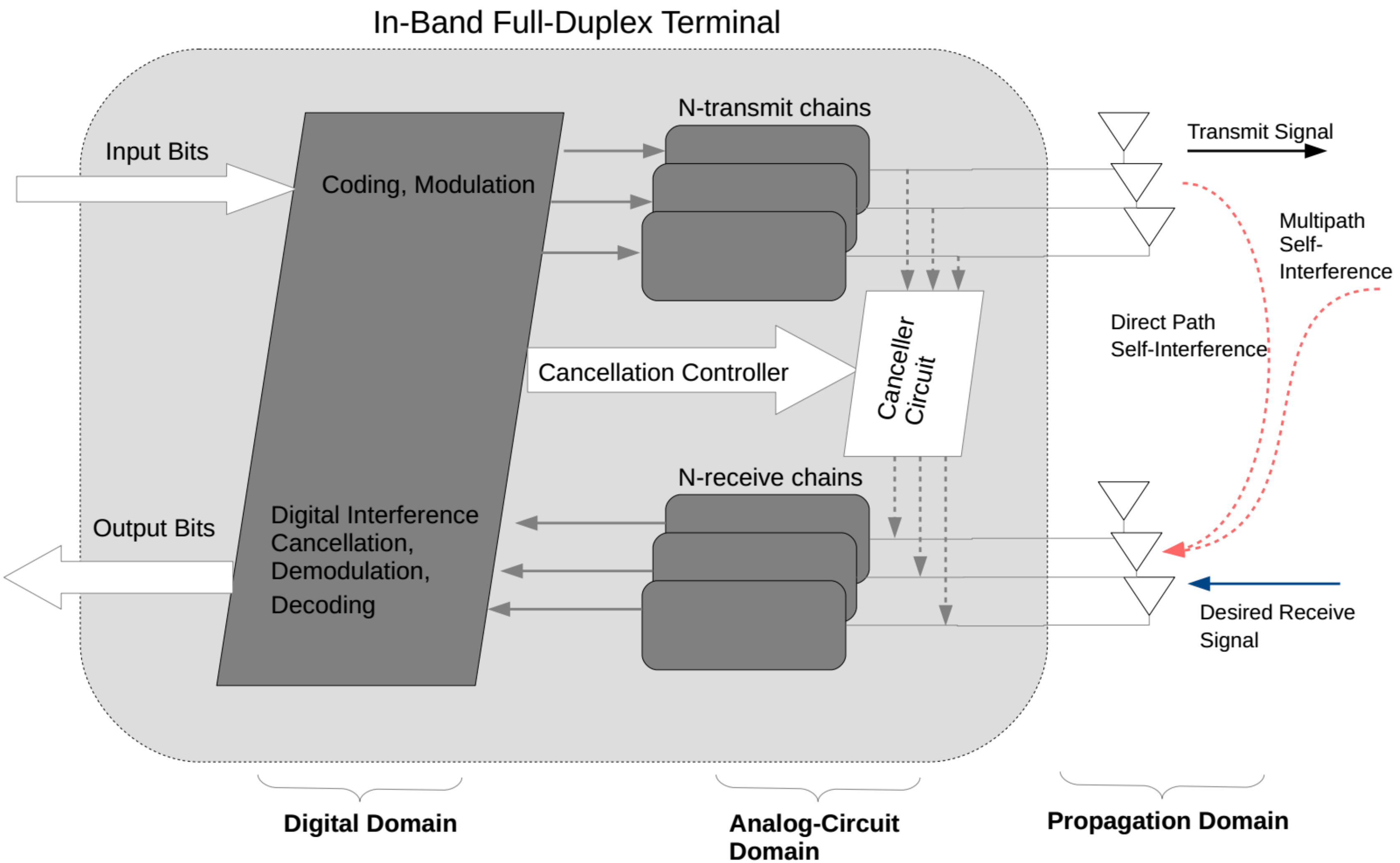
“Forgetting” factor

$$\widehat{MSE}_{RLS}(n, \mathbf{A}(z)) = \sum_{k=1}^{n} \lambda^{n-k} \left(\mathbf{f}(k) - \mathbf{A}(z)\tilde{\mathbf{t}}(k)\right)^H \left(\mathbf{f}(k) - \mathbf{A}(z)\tilde{\mathbf{t}}(k)\right)$$

OFDM-MIMO is used in our scheme



MIMO full-duplex device



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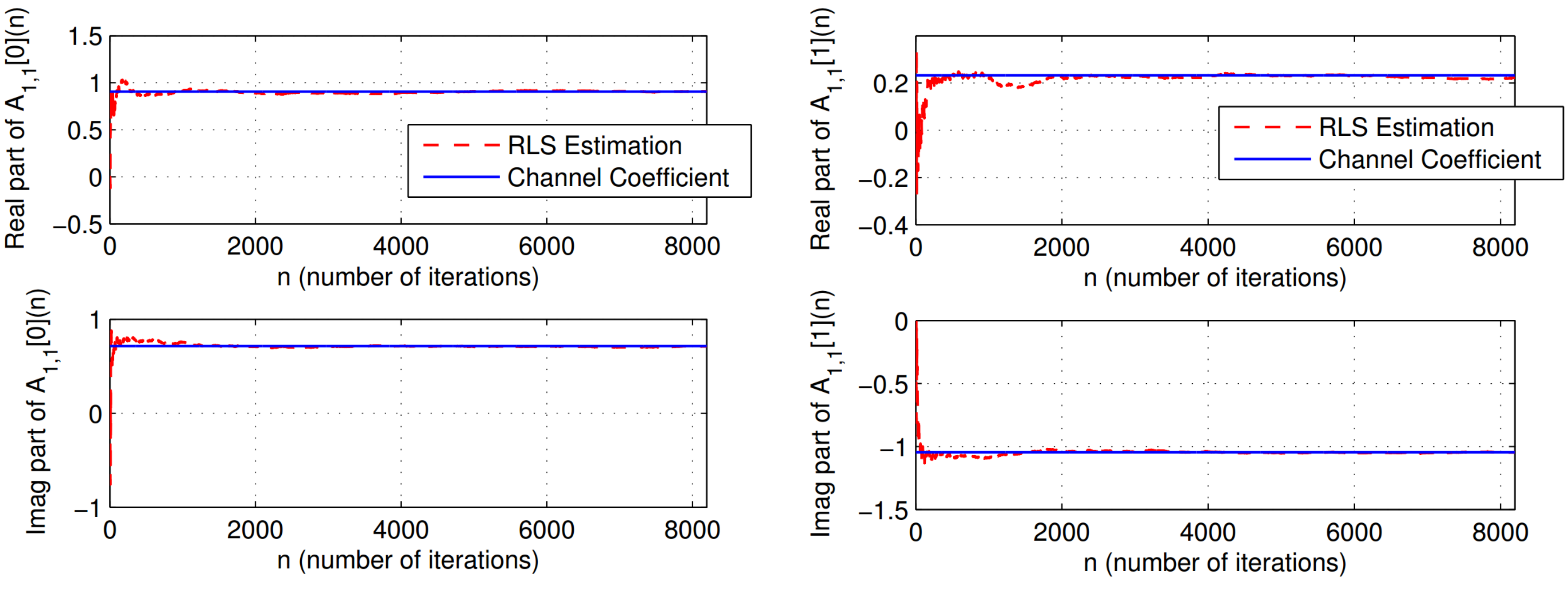
1- Context

2- Proposed System Model

3- Results

4- Conclusions

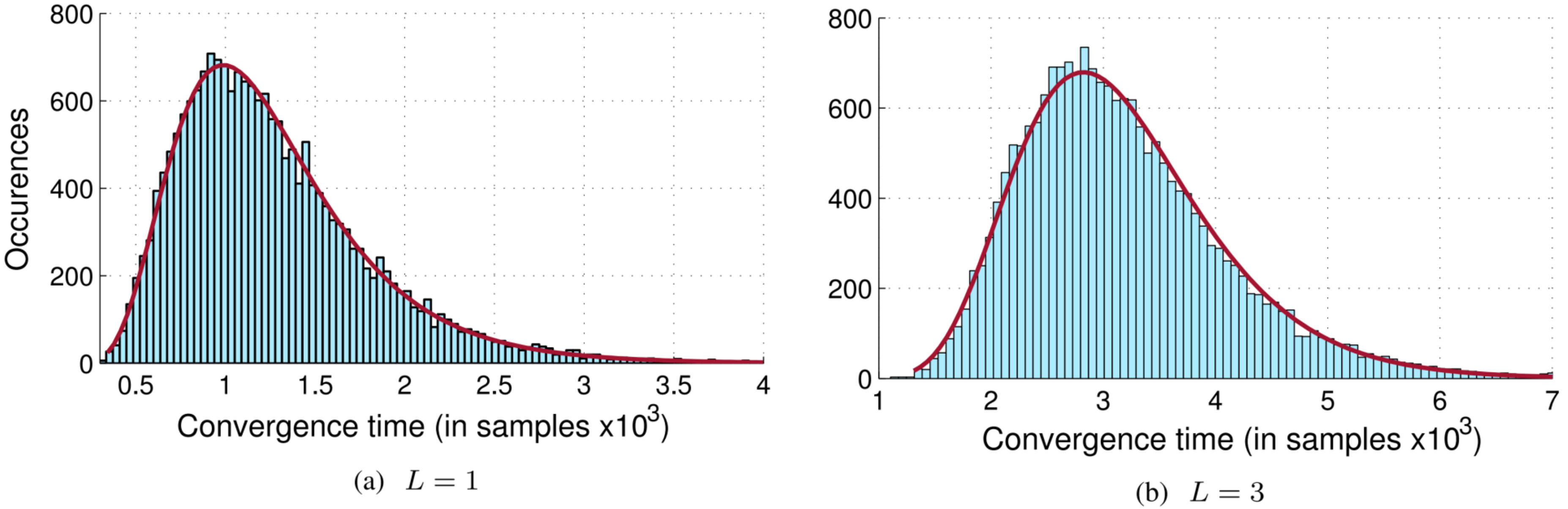
RLS estimation of self-interference matrix coefficients (with 16-QAM)



(a) $k = 0$ (b) $k = 1$

Note: the algorithms *always* converges.
(Proof in the paper)

Convergence "time" with 16-QAM



<u>Error metric:</u>

$$EM \leq \frac{\| \hat{\mathbf{A}}_{\star,n} - \mathbf{H}_{\mathbf{LI},\star} \|_F^2}{\| \mathbf{H}_{\mathbf{LI},\star} \|_F^2}$$

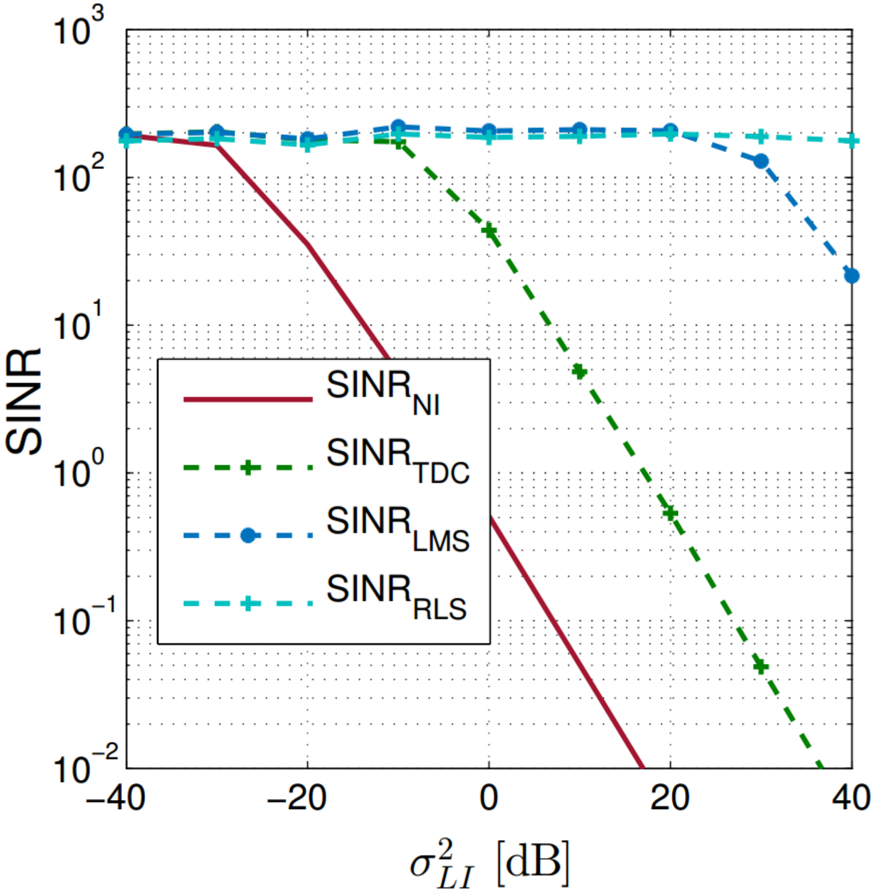
<u>Notes:</u>

i) the *EM* for the speady state is –42 dB, about (7dB better than with a LMS)

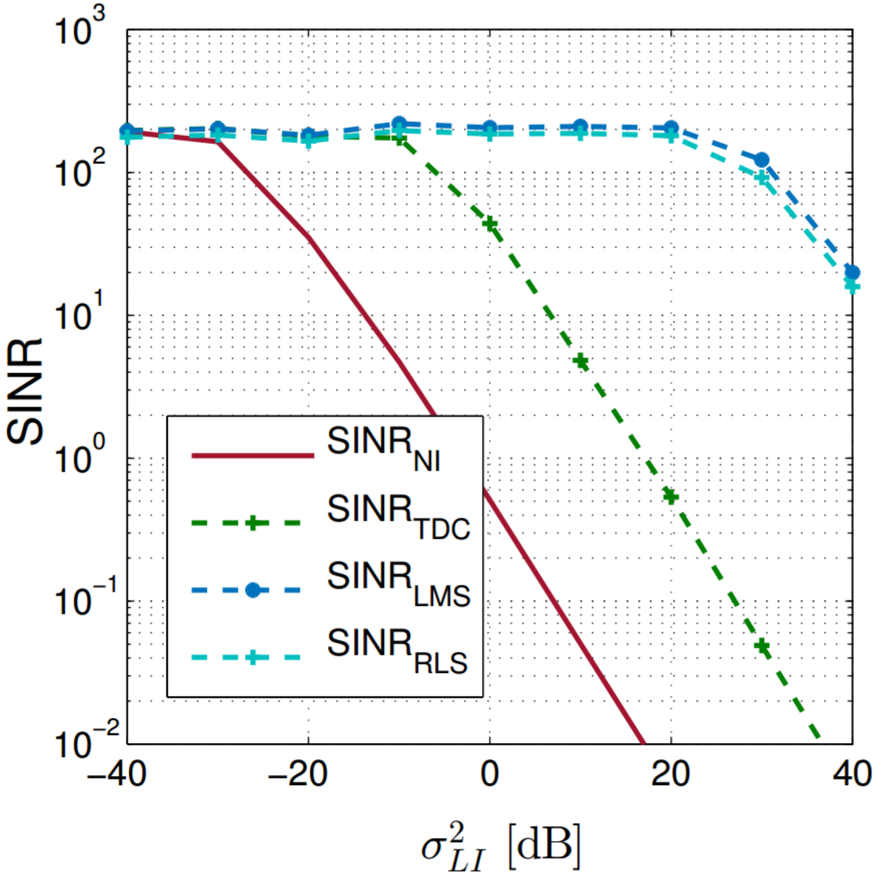
ii) convergence considered @ –30dB

iii) a log-normal pmf is observed

How loopback interference impacts on SINR

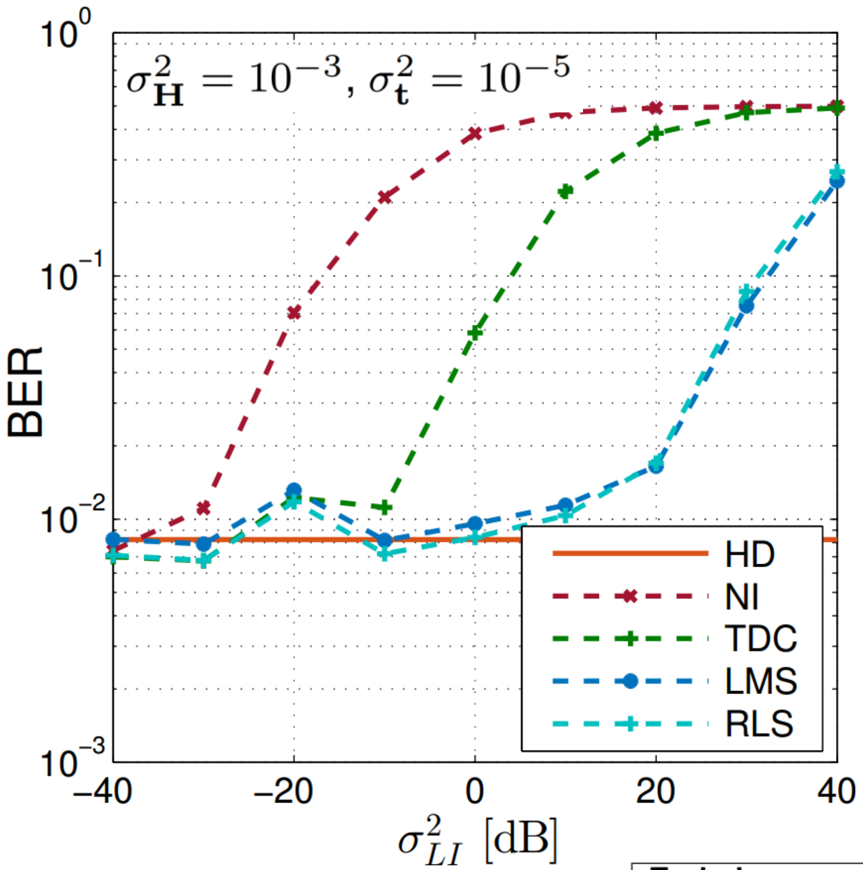


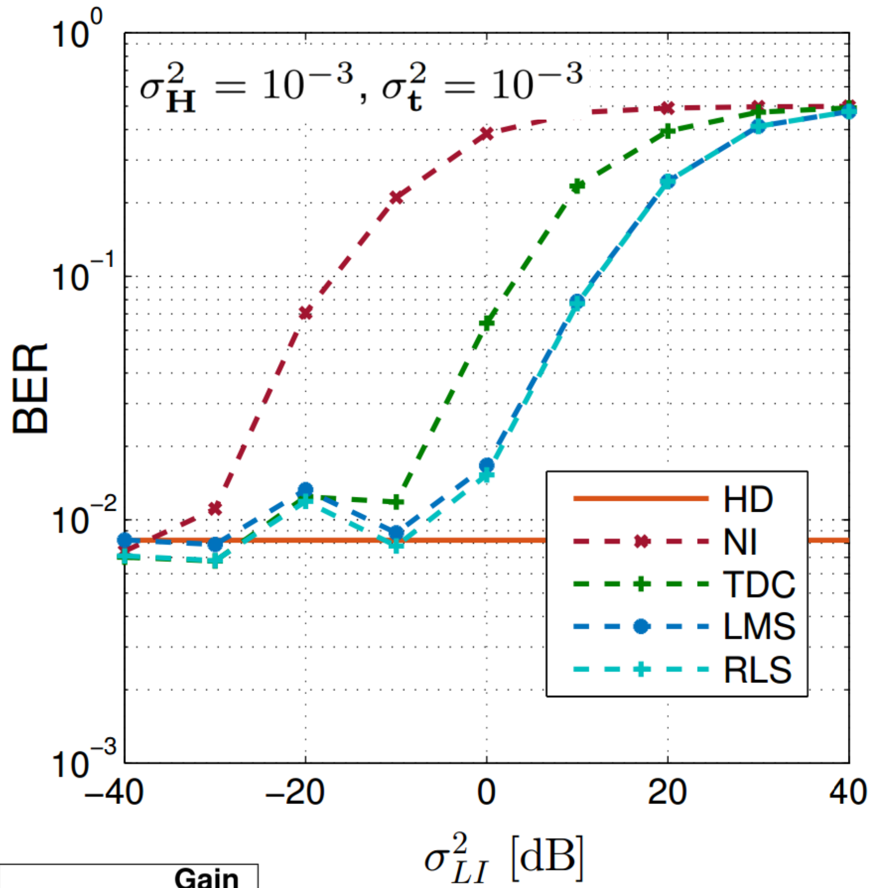
(a) $\sigma^2_{\mathbf{H}} = 10^{-3}$, $\sigma^2_{\mathbf{t}} = 10^{-5}$.



(b) $\sigma^2_{\mathbf{H}} = 10^{-3}$, $\sigma^2_{\mathbf{t}} = 10^{-3}$.

Protection to self-interference as a BER "resilience gain"





Technique	Gain
Natural Isolation	Reference (0 dB)
NSP	-20 dB
MMSE	-25 dB
LMS	-30 to -40 dB
RLS	-30 to -40 dB
Perfect Cancellation	$-\infty$ dB

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Conclusions

- Loopback self-interference cancelation is possible with Recursive Least Squares;
- RLS was derived for MIMO-OFDM
  (we were not able to find this in the literature);
- An update rule was derived;
- Convergence was proved and was always observed. Convergence time is negligible in comparison to the OFDM symbol length.

Acknowledgements

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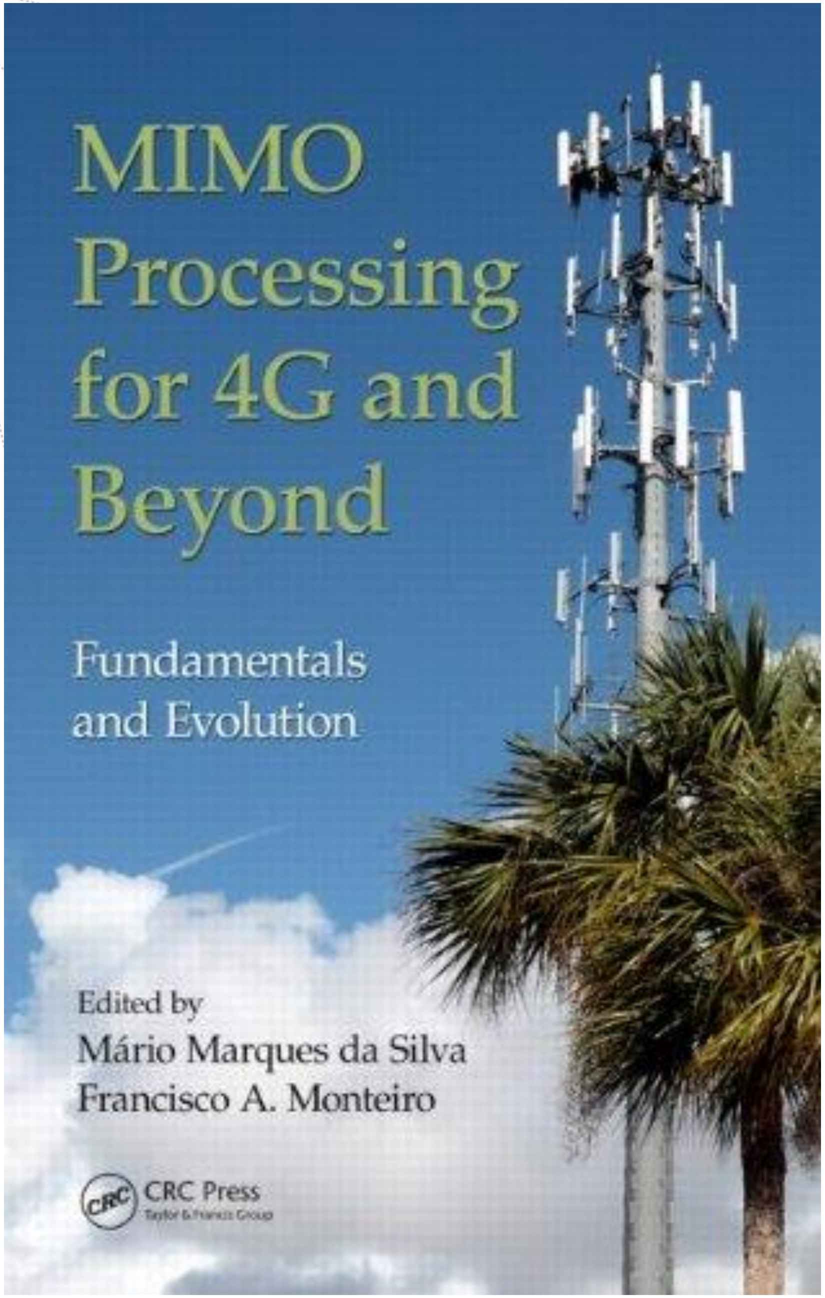
António Rodrigues (group leader)

Thank you

Back up slides



Includes an introduction to *MIMO detection techniques*

(CRC Press - Taylor and Francis, June 2014)