

# Secure Robust Resource Allocation using Full-Duplex Receivers



***ICC Workshop on WPLS, June 2015, London, UK***

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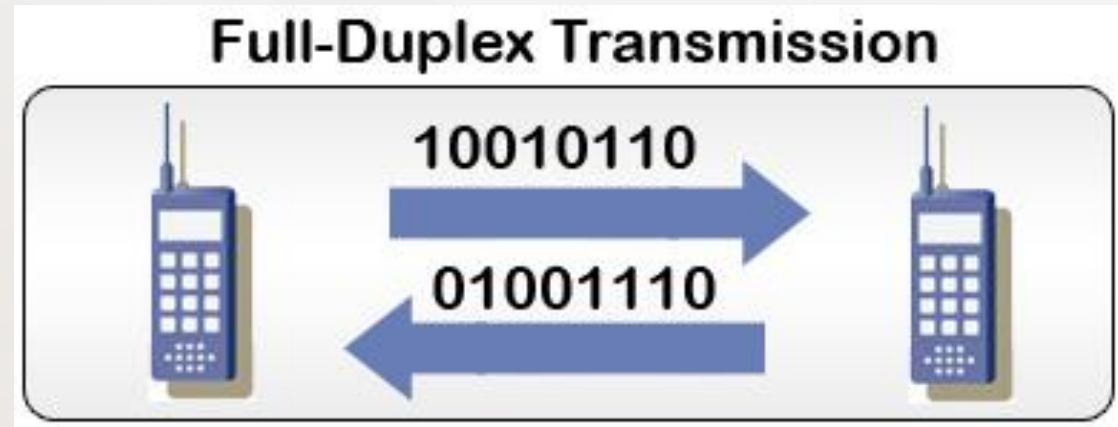
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# Motivation

- **PHY security**
- **Artificial noise: MIMO / Jamming Relay**
- **Robustness against CSI uncertainty**
- **FD receivers**
- **FD receivers used as jammers: no comparison has been ever made**

# Full-Duplex Receiver



Sender/Receiver

Sender/Receiver

# Robustness against CSI Uncertainty

*Channel Mismatch:*

$$e_{\mathbf{g}_{se}} = \mathbf{g}_{se} - \tilde{\mathbf{g}}_{se}$$

$$e_{\mathbf{g}_{je}} = \mathbf{g}_{je} - \tilde{\mathbf{g}}_{je}$$

$$e_{\mathbf{g}_{de}} = \mathbf{g}_{de} - \tilde{\mathbf{g}}_{de}$$

$$\mathcal{E}_{\mathbf{g}_{se}} = \{e_{\mathbf{g}_{se}} : \|e_{\mathbf{g}_{se}}\|^2 \leq \varepsilon_{\mathbf{g}_{se}}^2\}$$

$$\mathcal{E}_{\mathbf{g}_{je}} = \{e_{\mathbf{g}_{je}} : \|e_{\mathbf{g}_{je}}\|^2 \leq \varepsilon_{\mathbf{g}_{je}}^2\}$$

$$\mathcal{E}_{\mathbf{g}_{de}} = \{e_{\mathbf{g}_{de}} : \|e_{\mathbf{g}_{de}}\|^2 \leq \varepsilon_{\mathbf{g}_{de}}^2\}$$

# Literature on Cooperative Jamming (Perfect CSI)

L. Dong, Z. Han, A. P. Petropulu, and H. V. Poor, "Improving wireless physical layer security via cooperating relays," *IEEE Transactions on Signal Processing*, vol. 58, no. 3, pp. 1875–1888, March 2010.

G. Zheng, L. C. Choo, and K. K. Wong, "Optimal cooperative jamming to enhance physical layer security using relays," *IEEE Transactions on Signal Processing*, vol. 59, no. 3, pp. 1317–1322, March 2011.

I. Krikidis, J. S. Thompson, and S. McLaughlin, "Relay selection for secure cooperative networks with jamming," *IEEE Transactions on Wireless Communications*, vol. 8, no. 10, pp. 5003–5011, October 2009.

J. Vilela, M. Bloch, J. Barros, and S. W. McLaughlin, "Wireless secrecy regions with friendly jamming," *IEEE Transactions on Information Theory, Forensics Security*, vol. 6, no. 2, pp. 256–266, January 2011.

# Literature on Cooperative Jamming (Perfect CSI)

S. Gerbracht, C. Scheunert, and E. A. Jorswieck, "Secrecy outage in MISO systems with partial channel information," *IEEE Transactions on Information Theory, Forensics Security*, vol. 7, no. 2, pp. 704–716, April 2012.

S. Luo, J. Li, and A. Petropulu, "Outage constrained secrecy rate maximization using cooperative jamming," *Statistical Signal Processing Workshop (SSP)*, Ann Arbor, MI, USA, August 2012.

Z. Ding, M. Peng, and H.-H. Chen, "A general relaying transmission protocol for MIMO secrecy communications," *IEEE Transactions on Communications*, vol. 60, no. 11, pp. 3461–3471, November 2012.

Y. Liu, J. Li, and A. P. Petropulu, "Destination assisted cooperative jamming for wireless physical-layer security," *IEEE Transactions on Information Forensics and Security*, vol. 8, no. 4, pp. 682–694, April 2013.

# Literature on Cooperative Jamming (Imperfect CSI)

J. Huang and A. L. Swindlehurst, "Robust secure transmission in MISO channels based on worst-case optimization," *IEEE Transactions on Signal Processing*, vol. 60, no. 4, pp. 1696–1707, April 2012.

L. Zhang, Y.-C. Liang, Y. Pei, and R. Zhang, "Robust beamforming design: From cognitive radio MISO channels to secrecy MISO channels," in *Proc. Global Telecommunications Conference, (GLOBECOM)*, November 2009, pp. 1–5.

B. Yang, W. Wang, B. Yao, and Q. Yin, "Destination assisted secret wireless communication with cooperative helpers," *IEEE Signal Processing Letters*, vol. 20, no. 11, pp. 1030–1033, November 2013.

# Literature on FD jamming

W. Li, M. Ghogho, B. Chen, and C. Xiong, "Secure communication via sending artificial noise by the receiver: Outage secrecy capacity/region analysis," *IEEE Communications Letters*, vol. 16, no. 10, pp. 1628–1631, October 2012.

G. Zheng, I. Krikidis, J. Li, A. P. Petropulu, and B. Ottersten, "Improving physical layer secrecy using full-duplex jamming receivers," *IEEE Transactions on Signal*



# The HD Scenario

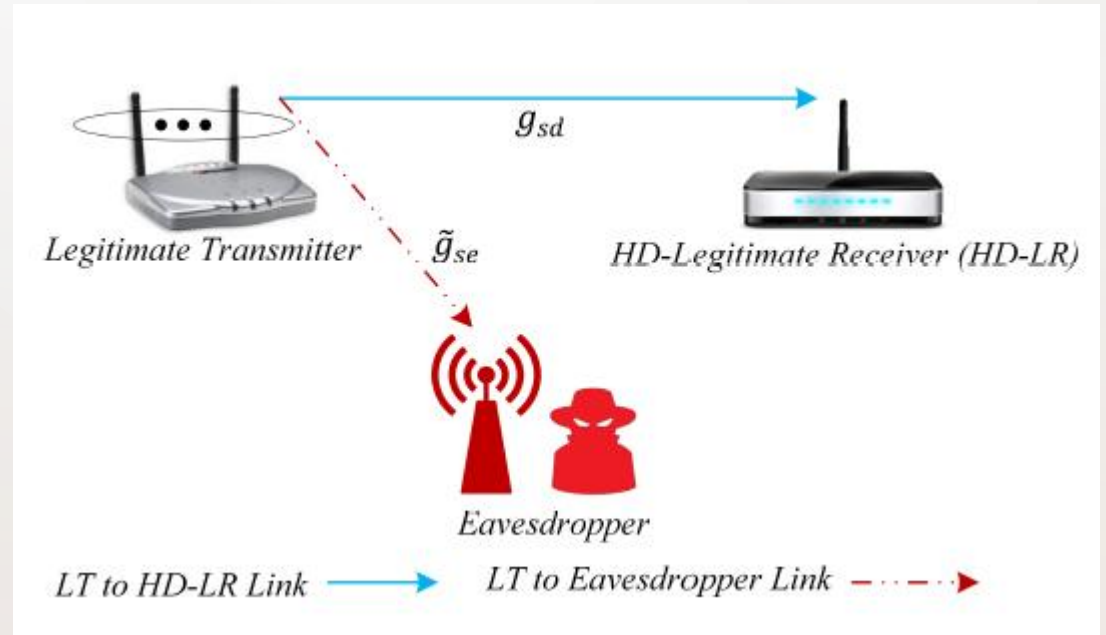
**Problem  $\mathcal{O}^{HD}$ :**

$$\max_{\mathbf{Q}_S \in \mathcal{Q}_S} \min_{e_{g_{se}} \in \mathcal{E}_{g_{se}}} R_S,$$

$$S.t. \quad \text{tr}(\mathbf{Q}_S) \leq P_S,$$

$$\|e_{g_{se}}\|^2 \leq \mathcal{E}_{g_{se}}^2,$$

$$\mathbf{Q}_S \succcurlyeq \mathbf{0}.$$



# The HDJ Scenario

**Problem  $\mathcal{O}^{HDJ}$ :**

$$\max_{\mathbf{Q}_s \in \mathcal{Q}_s, \mathbf{Q}_j \in \mathcal{Q}_j} \min_{e_{g_{se}} \in \mathcal{E}_{g_{se}}, e_{g_{je}} \in \mathcal{E}_{g_{je}}} R_s,$$

$$S. t. \quad \text{tr}(\mathbf{Q}_s) \leq P_s,$$

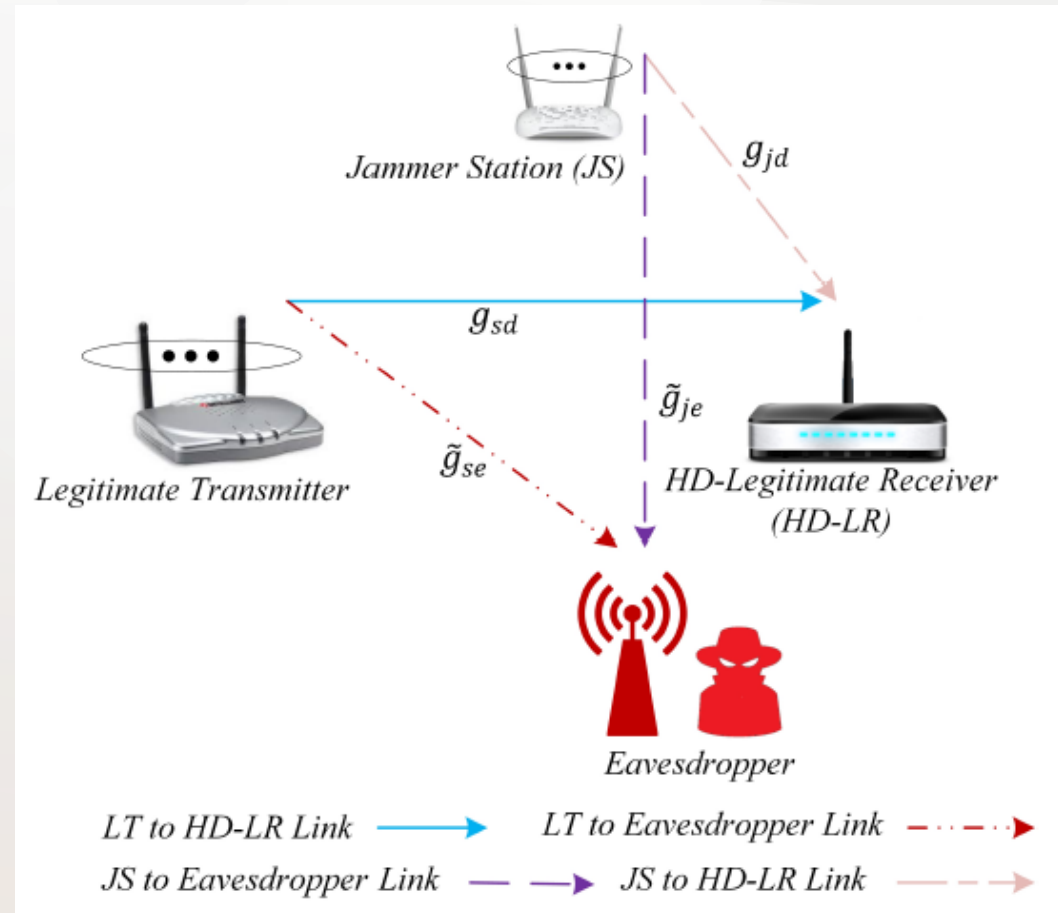
$$\|e_{g_{se}}\|^2 \leq \epsilon_{g_{se}}^2,$$

$$\mathbf{Q}_s \succeq \mathbf{0},$$

$$\text{tr}(\mathbf{Q}_j) \leq P_j,$$

$$\|e_{g_{je}}\|^2 \leq \epsilon_{g_{je}}^2,$$

$$\mathbf{Q}_j \succeq \mathbf{0}.$$



# The FD Scenario

**Problem  $\mathcal{O}^{FD}$ :**

$$\max_{\mathbf{Q}_s \in \mathcal{Q}_s, \mathbf{Q}_d \in \mathcal{Q}_d} \min_{\mathbf{e}_{g_{se}} \in \mathcal{E}_{g_{se}}, \mathbf{e}_{g_{de}} \in \mathcal{E}_{g_{de}}} R_s,$$

$$S. t. \quad \text{tr}(\mathbf{Q}_s) \leq P_s,$$

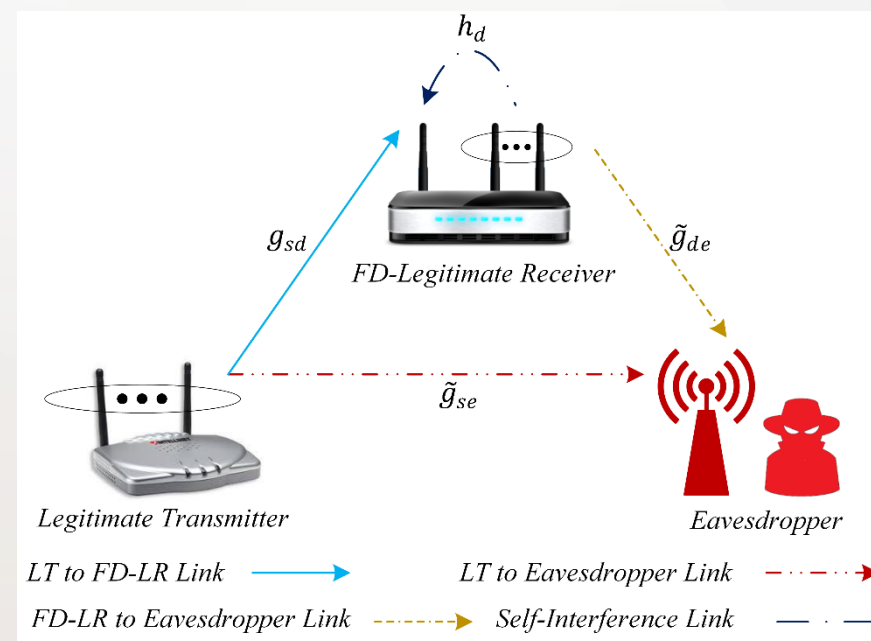
$$\|\mathbf{e}_{g_{se}}\|^2 \leq \mathcal{E}_{g_{se}}^2,$$

$$\mathbf{Q}_s \succeq \mathbf{0},$$

$$\text{tr}(\mathbf{Q}_d) \leq P_d,$$

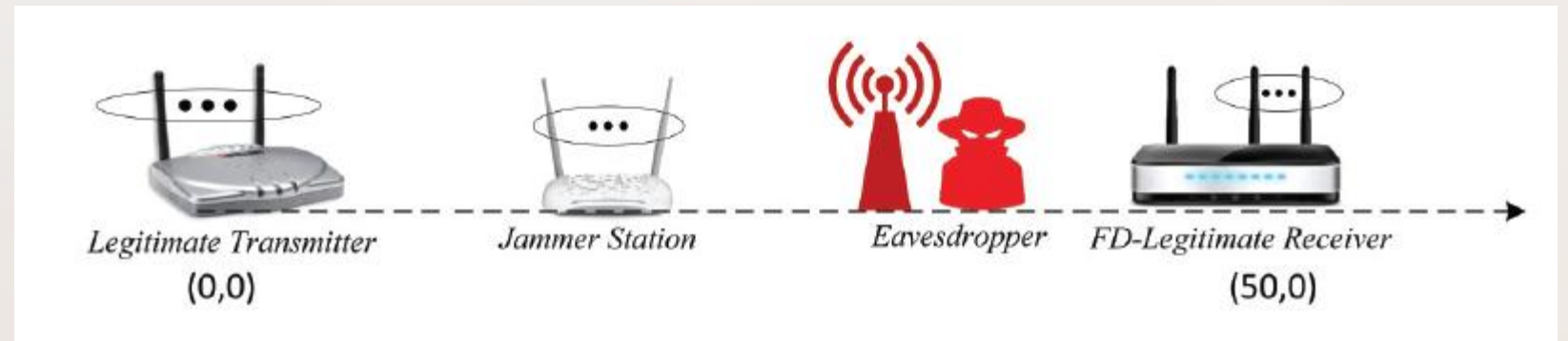
$$\|\mathbf{e}_{g_{de}}\|^2 \leq \mathcal{E}_{g_{de}}^2,$$

$$\mathbf{Q}_d \succeq \mathbf{0},$$

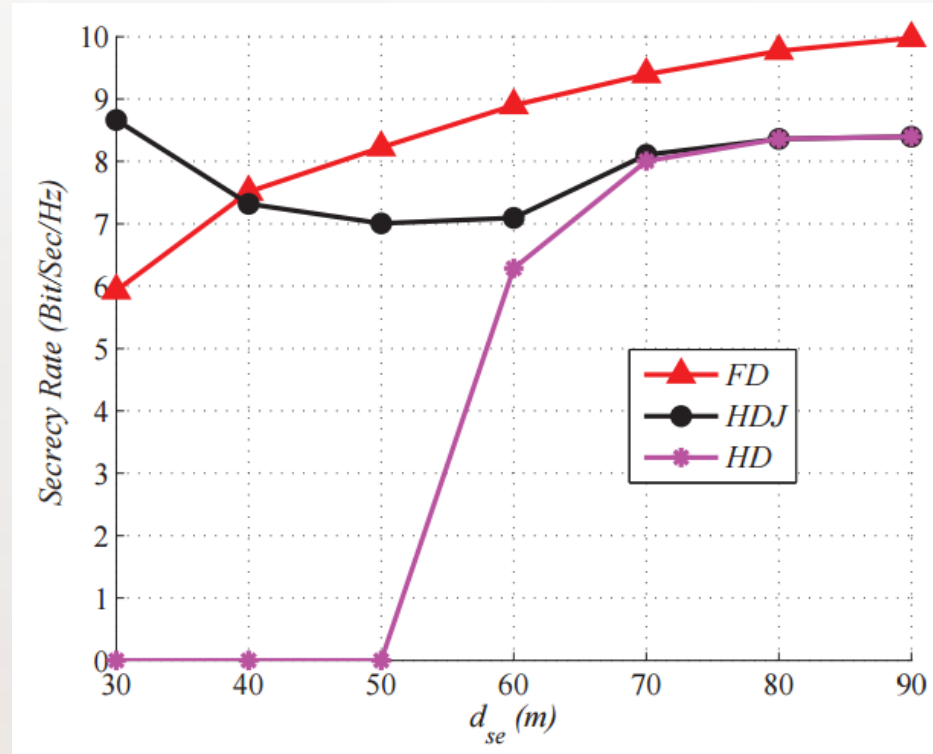


# Simulation Setup

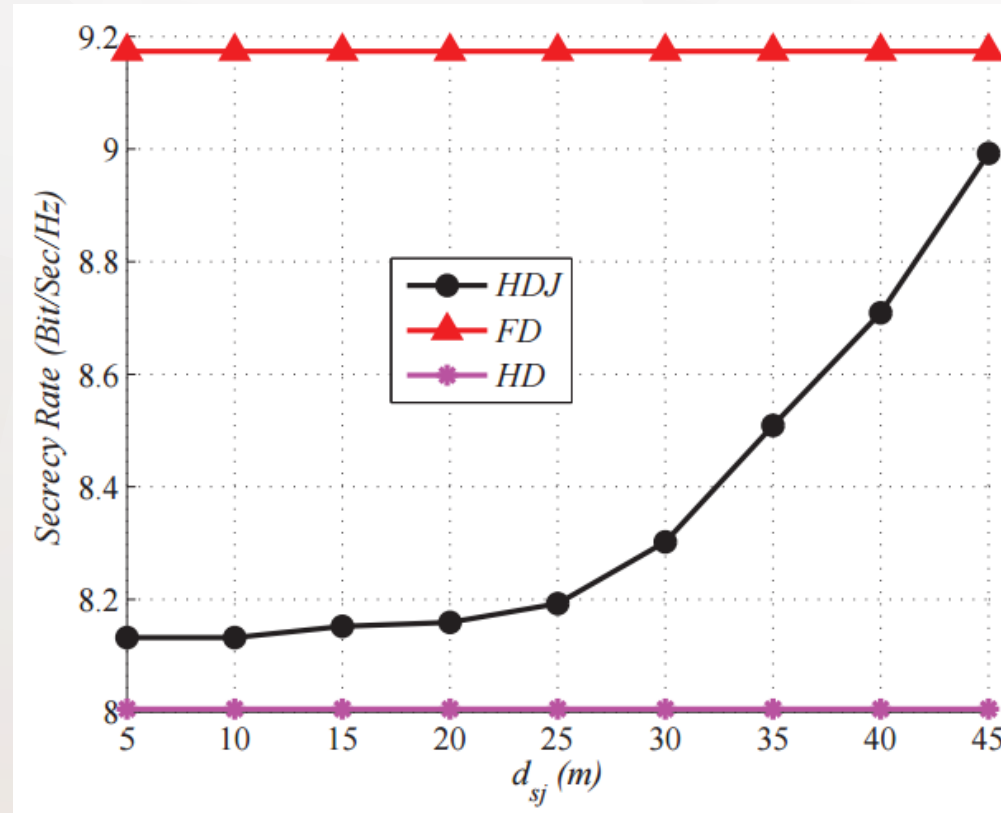
Parameter	Value
$N_s = N_d = N_j$	4
$\sigma_d^2 = \sigma_e^2$	0 dB
$\varepsilon_{g_{se}}^2 = \varepsilon_{g_{de}}^2 = \varepsilon_{g_{je}}^2$	0.5



## Simulation Results: Effect of Source-Eavesdropper Distance on the performance

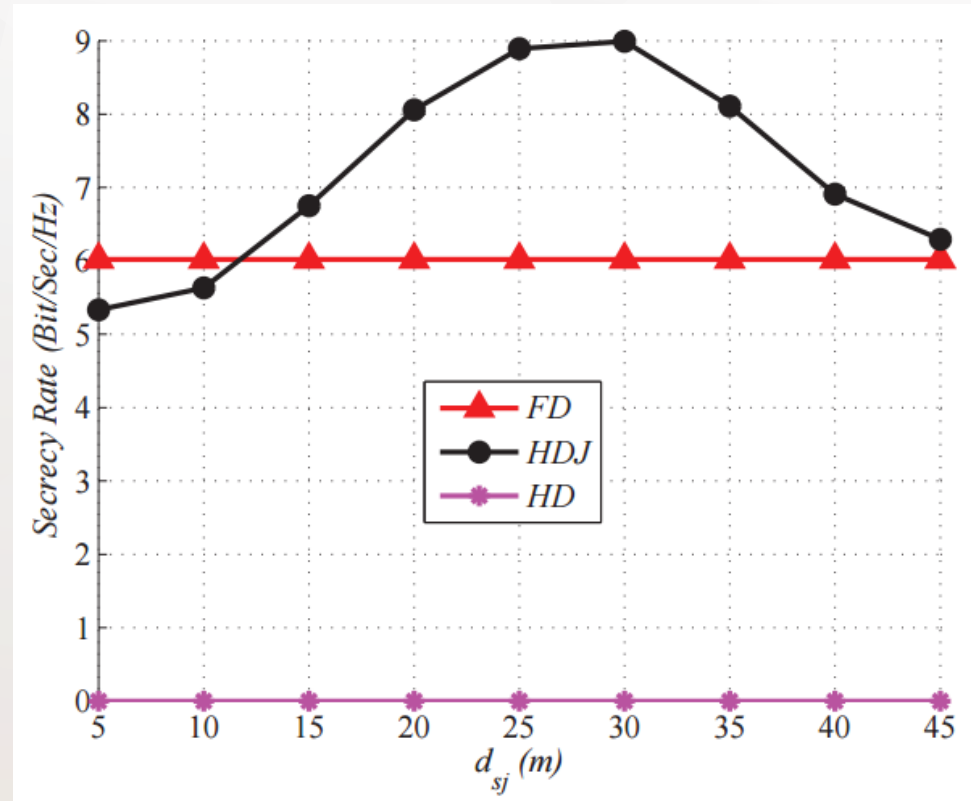


## Simulation Results: Effect of Source-Jammer Distance on the performance



Eavesdropper location is fixed at (30,0)

## Simulation Results: Effect of Source-Jammer Distance on the performance



Eavesdropper location is fixed at (70,0)

# Conclusion

- ❑ Preference of deploying the FD scenario over CJ, or vice versa, highly depends on where the jammer and eavesdropper are located.
- ❑ If the jammer can be placed close enough to the eavesdropper, a better performance is achieved compared to the FD system.
- ❑ Otherwise, the FD scenario can generally take over which is very favorable from practical point of view as we can remove the need for an extra network node.