

Secure Robust Resource Allocation using Full-Duplex Receivers



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M. R. Abedi, Modares University, Iran

N. Mokari, Modares University, Iran

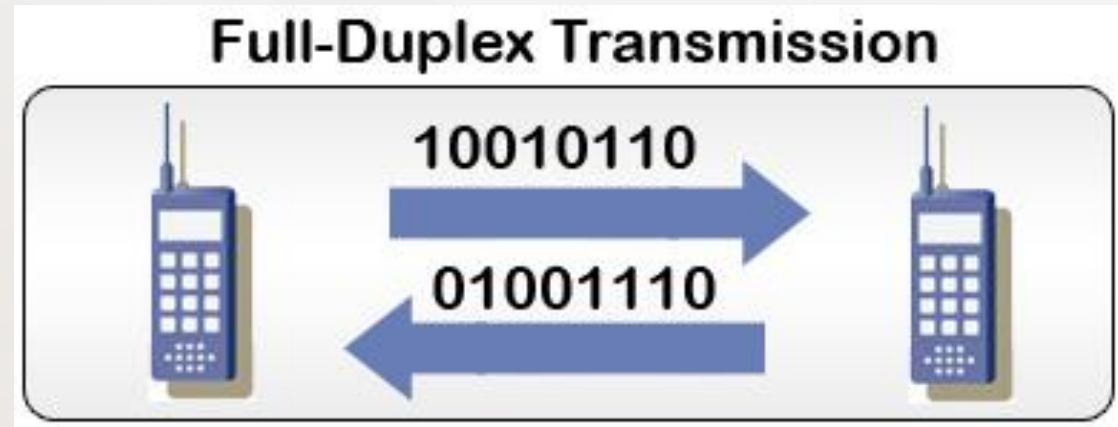
H. Saeedi, Modares University, Iran

H. Yanikomeroglu, Carleton University, Canada

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

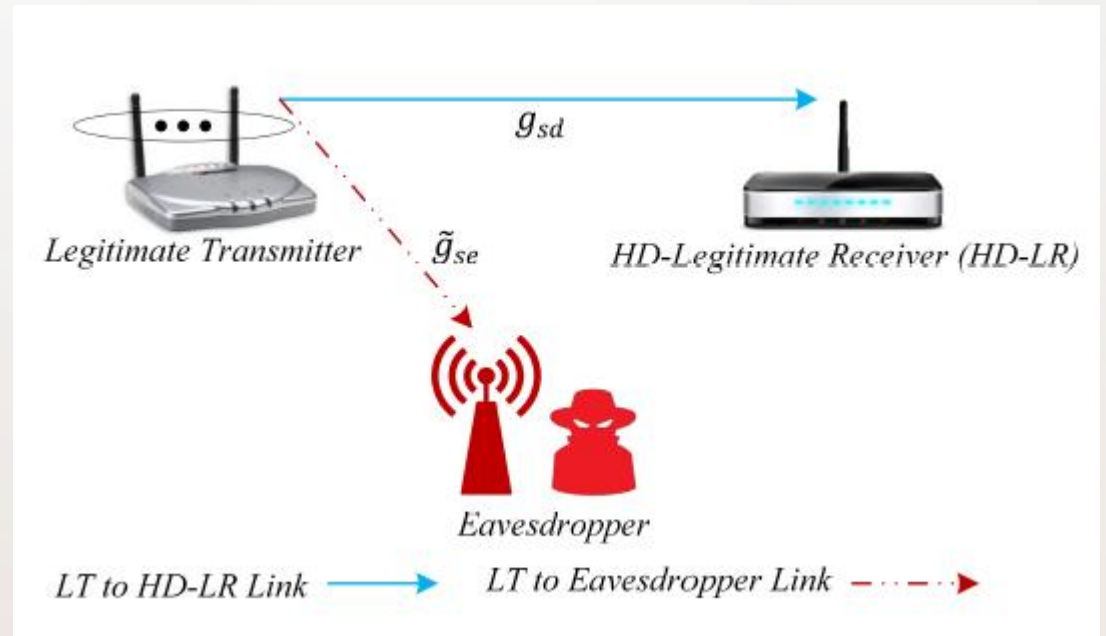
Problem \mathcal{O}^{HD} :

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

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

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

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



The HDJ Scenario

Problem \mathcal{O}^{HDJ} :

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

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

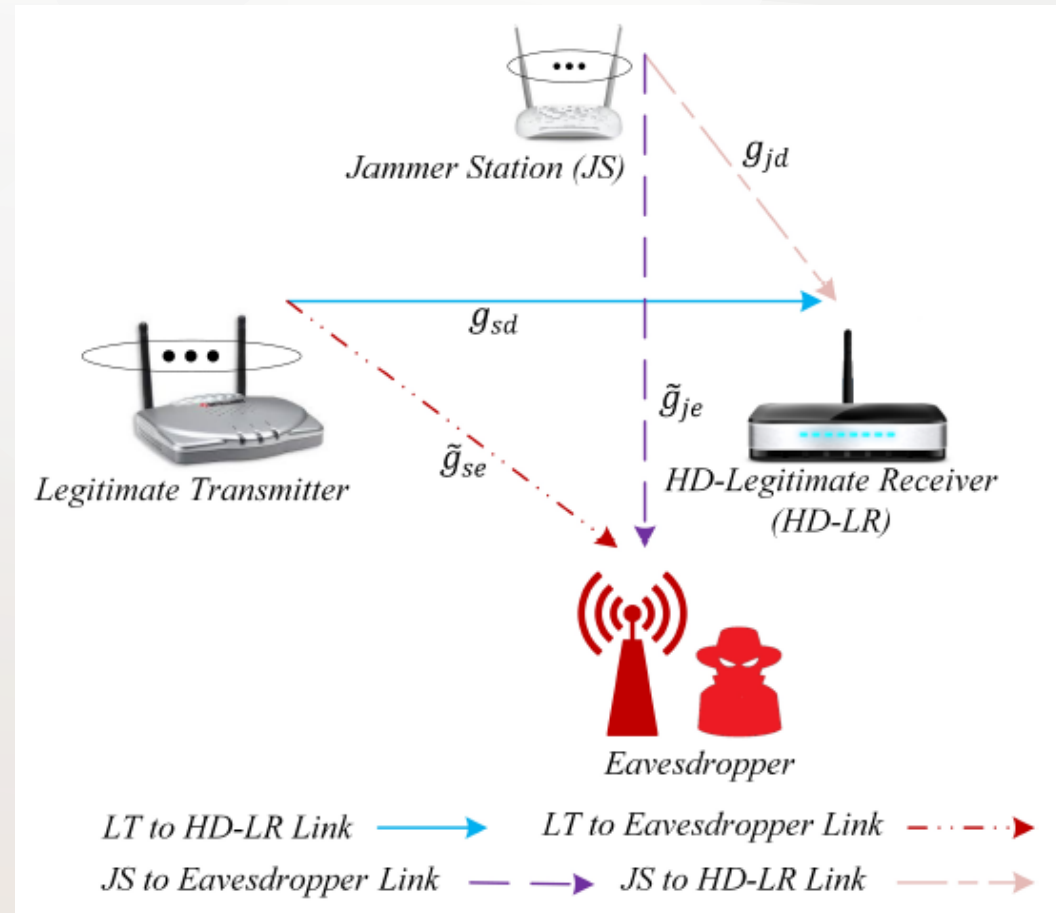
$$\|e_{g_{se}}\|^2 \leq \epsilon_{g_{se}}^2,$$

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

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

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

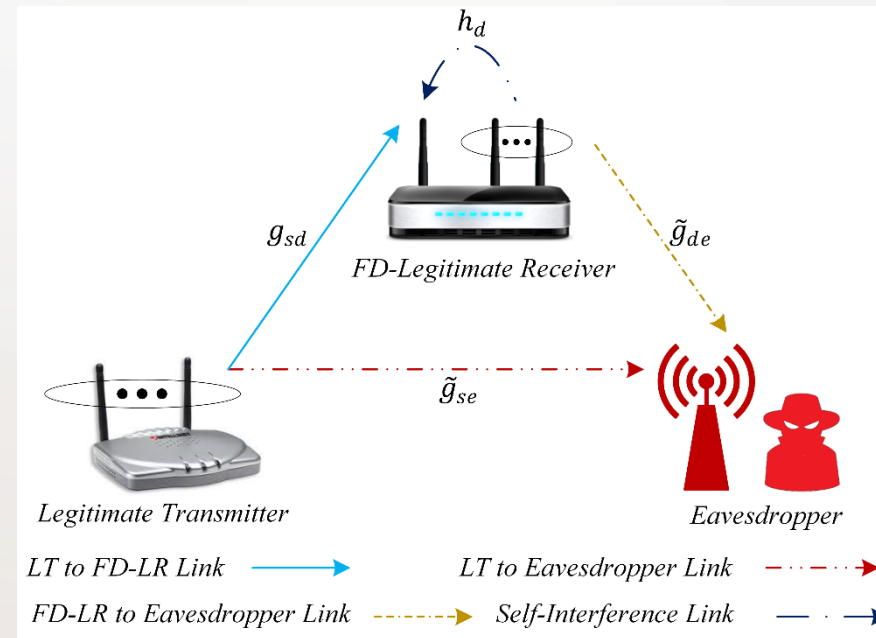
$$\mathbf{Q}_j \succeq \mathbf{0}.$$



The FD Scenario

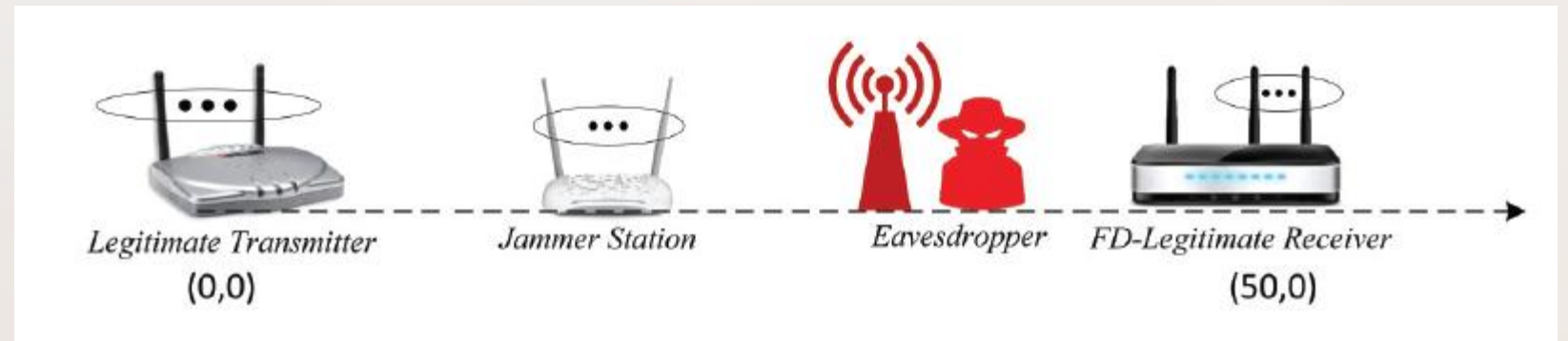
Problem \mathcal{O}^{FD} :

$$\begin{aligned} & \max_{\mathbf{Q}_s \in \mathcal{Q}_s, \mathbf{Q}_d \in \mathcal{Q}_d} \min_{e_{g_{se}} \in \mathcal{E}_{g_{se}}, e_{g_{de}} \in \mathcal{E}_{g_{de}}} R_s, \\ & \text{s.t.} \quad \text{tr}(\mathbf{Q}_s) \leq P_s, \\ & \quad \quad \|e_{g_{se}}\|^2 \leq \mathcal{E}_{g_{se}}^2, \\ & \quad \quad \mathbf{Q}_s \succeq \mathbf{0}, \\ & \quad \quad \text{tr}(\mathbf{Q}_d) \leq P_d, \\ & \quad \quad \|e_{g_{de}}\|^2 \leq \mathcal{E}_{g_{de}}^2, \\ & \quad \quad \mathbf{Q}_d \succeq \mathbf{0}, \end{aligned}$$

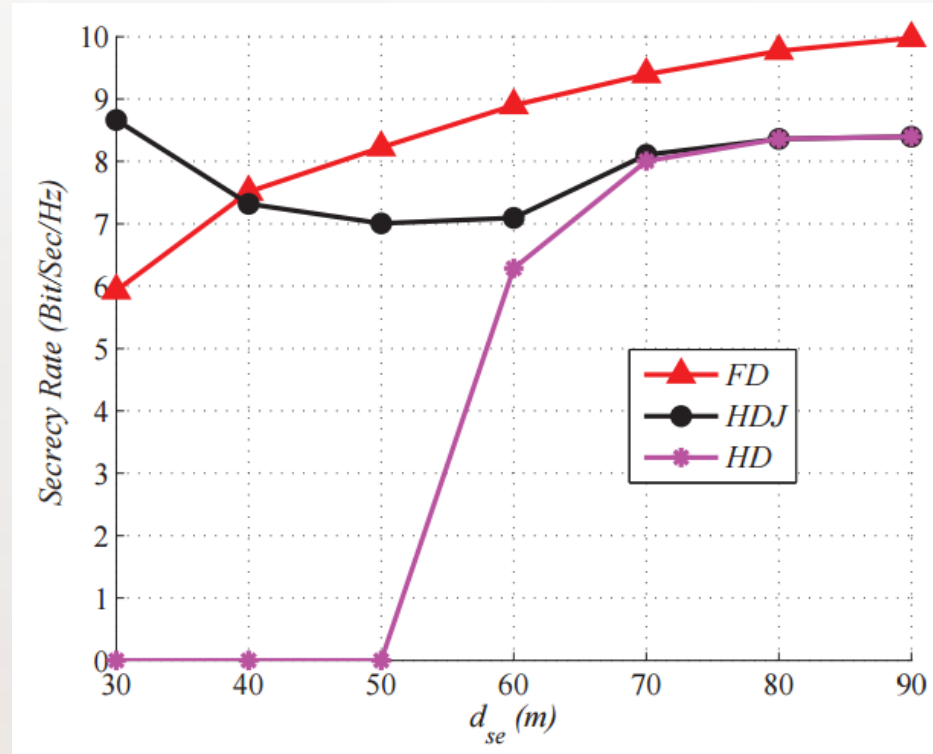


Simulation Setup

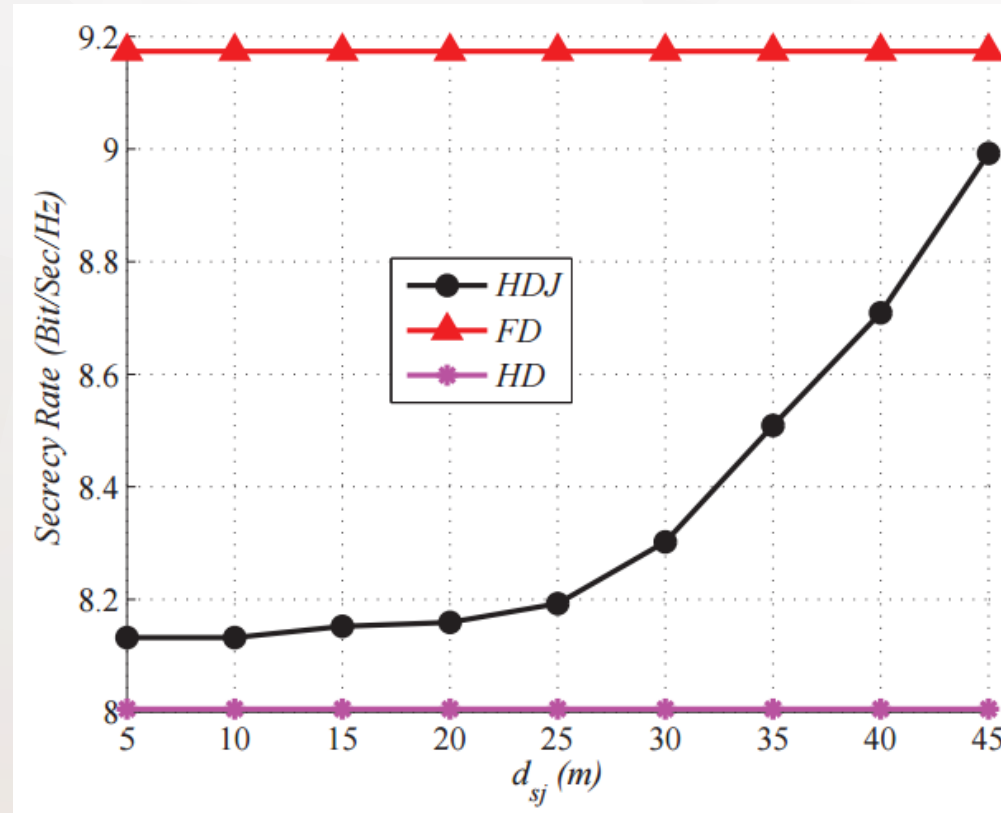
Parameter	Value
$N_s = N_d = N_j$	4
$\sigma_d^2 = \sigma_e^2$	0 dB
$\varepsilon_{g_{se}}^2 = \varepsilon_{g_{de}}^2 = \varepsilon_{g_{je}}^2$	0.5



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

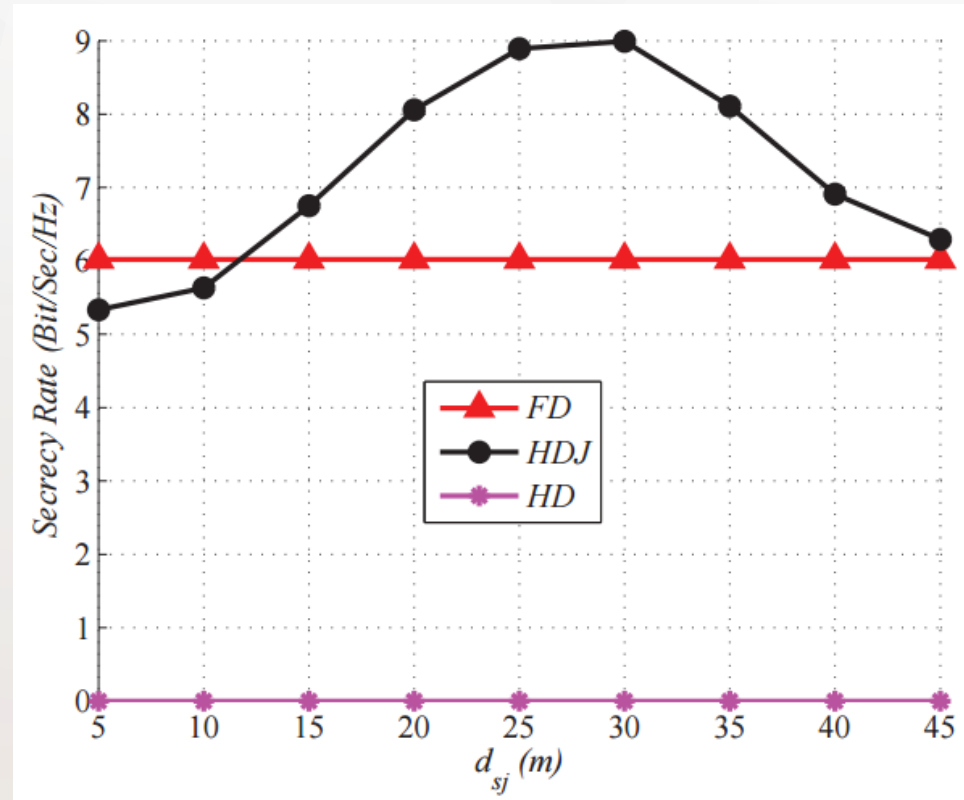


Simulation Results: Effect of Source-Jammer Distance on the performance



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.