Comment on "Relay selection for secure cooperative networks with jamming"

Comment on "Relay Selection for Secure Cooperative Networks with Jamming"

Gaojie Chen, Vincent Dwyer, Ioannis Krikidis, John S. Thompson, Steve McLaughlin and Jonathon Chambers

Abstract—**It is the purpose of the note to point out that the Cumulative Distribution Function (CDF) (Eq. (23)) in Appendix A in the paper "Relay Selection for Secure Cooperative Networks with Jamming" by Krikidis et al. (IEEE Trans. Wireless Commun., vol. 8, no. 10, pp. 5003-5011, Oct. 2009) is not the exact expression but an approximation. We provide the exact solution of the CDF in two forms: one using Beta and hypergeometric functions and the second exploiting a recurrence relationship.**

***Index Terms*—**

I. Introduction

In the above paper [1], Eq. (23) in Appendix A, which denotes the Cumulative Distribution Function (CDF) of $\mathcal{Z} \triangleq Z_1/Z_2$, is not exact but an approximation. The CDF is given by

$$\begin{aligned} P_{\mathcal{Z}}(y) &= \mathbb{P}\left\{\frac{Z_1}{Z_2} < y\right\} = \int_0^\infty P_{Z_1}(z_2 y) p_{Z_2}(z_2) dz_2 \\ &= (K-1)y^K \int_0^\infty \left[\frac{z_2}{(1+z_2 y)(1+z_2)}\right]^K dz_2 \\ &= \frac{y^K}{2^K-(1+y)^K}\left(\frac{1}{y}-1\right), \end{aligned} \quad (1)$$

where K is the integer number of available decode and forward (DF) relays. This expression is needed in [1] to calculate the secrecy outage probability, when $y = 2^{2Rs}$, where $Rs > 0$ is a target secrecy rate.

In particular for $K \geq 2$ the equality given in the last line of (1) is incorrect, because

$$\int_0^\infty \left[\frac{z_2}{(1+z_2 y)(1+z_2)}\right]^K dz_2 \approx \frac{y-1}{y[2^K-(1+y)^K](K-1)}. \quad (2)$$

We therefore show correct forms of the solution to this integral. We first define

$$I_K = \int_0^\infty \left[\frac{z}{(1+zy)(1+z)}\right]^K dz, \quad (3)$$

a solution for which can be found in [2], (pp. 317, Eq. 3.197.5), as

$$I_K = B(K+1, K-1) F_1(K, K+1; 2K; 1-y), \quad (4)$$

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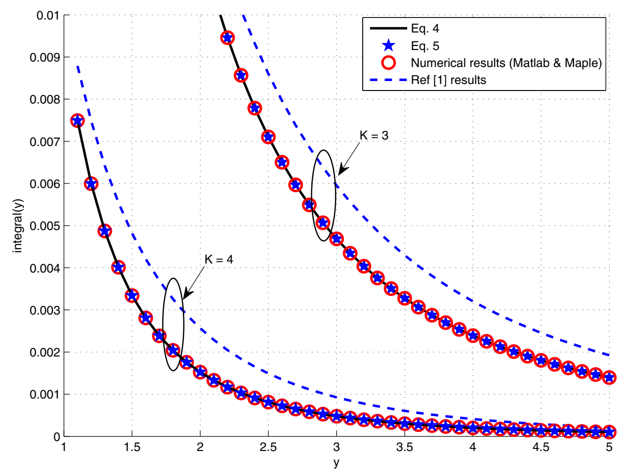

Fig. 1. The comparison between the numerical evaluation of (3) and the result given in [1] and the results in (4) and (5).

where $B(\cdot)$ denotes the Beta function and $F_1(\cdot)$ denotes the hypergeometric function; and a second solution which only requires elementary functions, as

$$I_K = \frac{4}{(2\sqrt{y})^{K+1}\sinh(\alpha)}\left[\frac{-\cosh(\alpha)I'_{K-1}}{\sinh^{2K-2}(\alpha)} + \frac{I'_{K-2}}{\sinh^{2K-4}(\alpha)}\right], \quad (5)$$

where $I'_K = [(2K-1)\cosh(\alpha)I'_{K-1} - (K-1)\sinh^2(\alpha)I'_{K-2}]/K$ with $I'_0 = \alpha = \log(y)/2$ and $I'_1 = \alpha\cosh(\alpha) - \sinh(\alpha)$.

To confirm that Eqs. (4) and (5) are correct solutions for (3), when K is an integer greater than unity, we show Fig. 1 which denotes the comparison between the numerical evaluation of (3) and the results given in [1] and our results. It can be seen that the accuracy of (2) improves as K increases. Thus, we have provided methods both to bound and correctly evaluate the CDF presented in Eq. (23) in [1]. Otherwise, the results presented in [1] are unchanged and the new selection polices for a cooperative network with secrecy constraints are correct.

References

[1] I. Krikidis, J. S. Thompson, and S. McLaughlin, "Relay selection for secure cooperative networks with jamming," *IEEE Trans. Wireless. Commun.*, vol. 8, no. 10, pp. 5003-5010, Oct. 2009.

[2] I. S. Gradshteyn and I. M. Rhzik, *Table of Integrals, Series, and Products*, 7th edition. Academic Press, 2007.