

The utility of the smart jammer at time slot k denoted by $u_J^{(k)}$ is given by

$$u_J^{(k)} = -\max\left(\frac{Ph_1^{(k)}}{\sigma + y^{(k)}h_3^{(k)}}, \min\left(\frac{Ph_2^{(k)}}{\sigma + y^{(k)}h_4^{(k)}}, \frac{x^{(k)}h_5^{(k)}}{\sigma}\right)\right) + x^{(k)}C_U - y^{(k)}C_J, \quad (1)$$

and the time index k is omitted in the superscript.

Theorem 1. *The UAV applying Algorithm 1 in the dynamic UAV relay game can achieve the optimal policy $(0, 0)$, if*

$$\begin{aligned} & \max\left(\frac{Ph_1h_3}{\sigma^2}, \frac{Ph_2h_4}{\sigma^2}, \frac{Ph_2h_4(h_3\sqrt{h_2h_4} - h_4\sqrt{h_1h_3})^2}{\sigma^2(\sqrt{h_1h_3}(1-h_4) + \sqrt{h_2h_4}(h_3-1))^2}\right) \\ & < C_J \leq \frac{Ph_1h_3(h_3\sqrt{h_2h_4} - h_4\sqrt{h_1h_3})^2}{\sigma^2(\sqrt{h_1h_3}(1-h_4) + \sqrt{h_2h_4}(h_3-1))^2} \end{aligned} \quad (2)$$

$$C_U \geq \frac{h_5}{\sigma}, \quad (3)$$

and the corresponding BER with QPSK is given by

$$P_e = \frac{1}{2}\text{erfc}\left(\frac{Ph_1}{\sigma}\right). \quad (4)$$

Proof: By (1), if (3) holds, we have

$$\frac{\partial u(x, 0)}{x} = \frac{h_5}{\sigma} - C_U \leq 0, \quad (5)$$

thus the utility u is decreases with respect to (w.r.t.) x , and we have

$$u(0, 0) = \frac{Ph_1}{\sigma} \geq \max\left(\frac{Ph_1}{\sigma}, \min\left(\frac{Ph_2}{\sigma}, \frac{xh_5}{\sigma}\right)\right) - xC_U = u(x, 0). \quad (6)$$

By (1), if (2) holds, we have

$$\frac{\partial u_J(0, y)}{y} = -\max\left(\frac{-Ph_1h_3}{(\sigma + yh_3)^2}, \frac{-Ph_2h_4}{(\sigma + yh_4)^2}\right) - C_J \quad (7)$$

$$\frac{\partial^2 u_J(0, y)}{\partial y^2} = -\max\left(\frac{2Ph_1h_3^2}{(\sigma + yh_3)^3}, \frac{2Ph_2h_4^2}{(\sigma + yh_4)^3}\right) \leq 0, \quad (8)$$

indicating that $u_J(0, y)$ is concave with respect to (w.r.t.) y . Thus, $\forall y \in [0, P_J^M]$, we have

$$u_J(0, 0) = -\frac{Ph_1}{\sigma} \geq -\frac{Ph_1}{\sigma + yh_3} = u_J(0, y). \quad (9)$$

Thus, the optimal policy is $(0, 0)$. According the QPSK modulation, we have

$$P_e = \frac{1}{2}\text{erfc}\left(\frac{Ph_1}{\sigma}\right). \quad (10)$$

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