



Supplementary materials for

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Proof S1 Proof of Eq. (23)

The first partial derivative of the utility function with respect to $p_{R(kl)}$ is obtained, and now make it zero:

$$\frac{\partial U_{R(kl)}(p_{R(kl)}, p_{J(jk)})}{\partial p_{R(kl)}} = \frac{\frac{\partial \gamma_{R(kl)}}{\partial p_{R(kl)}}}{\gamma_{R(kl)} - \gamma_{R(kl)}^{\min}} - \varepsilon_{kl} = \frac{\gamma_{R(kl)}}{p_{R(kl)} (\gamma_{R(kl)} - \gamma_{R(kl)}^{\min})} - \varepsilon_{kl} = 0, \quad (S1)$$

$$\begin{aligned} \Rightarrow p_{R(kl)} (\gamma_{R(kl)} - \gamma_{R(kl)}^{\min}) \varepsilon_{kl} &= \gamma_{R(kl)}, \\ \Rightarrow \gamma_{R(kl)} (\varepsilon_{kl} p_{R(kl)} - 1) &= \varepsilon_{kl} \gamma_{R(kl)}^{\min} p_{R(kl)}. \end{aligned}$$

Substituting Eqs. (15) and (16) into Eq. (S1), Eq. (23) is obtained.

Proof S2 Proof of Eq. (25)

The first partial derivative of the utility function with respect to $p_{J(jk)}$ is obtained, and now make it zero:

$$\frac{\partial U_{R(kl)}(p_{R(kl)}, p_{J(jk)})}{\partial p_{J(jk)}} = \frac{\frac{\partial \gamma_{R(kl)}}{\partial p_{J(jk)}}}{\gamma_{R(kl)} - \gamma_{R(kl)}^{\min}} + \omega_{jk} = \frac{-\frac{p_{R(kl)} |\mathbf{w}_{r(kl)}^H \hat{\mathbf{h}}_{t(kl)}|^2 |\mathbf{w}_{r(kl)}^H \hat{\mathbf{c}}_{t(jk)}|^2}{I_{R(kl)}^2}}{\gamma_{R(kl)} - \gamma_{R(kl)}^{\min}} + \omega_{jk} = 0, \quad (S2)$$

$$\Rightarrow I_{R(kl)}^2 (\gamma_{R(kl)} - \gamma_{R(kl)}^{\min}) = \frac{p_{R(kl)} |\mathbf{w}_{r(kl)}^H \hat{\mathbf{h}}_{t(kl)}|^2 |\mathbf{w}_{r(kl)}^H \hat{\mathbf{c}}_{t(jk)}|^2}{\omega_{jk}}.$$

Substituting Eqs. (15) and (16) into Eq. (S2), Eq. (25) is obtained.

Proof S3 Proof of inequality (28)

The second-order mixed partial derivative of the utility function to the strategies of both sides of the radars and jammers is greater than or equal to zero:

$$\begin{aligned} \frac{\partial^2 U_{R(kl)}(p_{R(kl)}, p_{J(jk)})}{\partial p_{J(jk)} \partial p_{R(kl)}} &= \frac{\partial \left(\frac{\gamma_{R(kl)}}{p_{R(kl)} (\gamma_{R(kl)} - \gamma_{R(kl)}^{\min})} - \varepsilon_{kl} \right)}{\partial p_{J(jk)}} = -\frac{\frac{\partial \gamma_{R(kl)}}{\partial p_{J(jk)}} \gamma_{R(kl)}^{\min}}{p_{R(kl)} (\gamma_{R(kl)} - \gamma_{R(kl)}^{\min})} \\ &= \frac{|\mathbf{w}_{r(kl)}^H \hat{\mathbf{h}}_{t(kl)}|^2 |\mathbf{w}_{r(kl)}^H \hat{\mathbf{c}}_{t(jk)}|^2 \gamma_{R(kl)}^{\min}}{I_{R(kl)}^2 (\gamma_{R(kl)} - \gamma_{R(kl)}^{\min})} \geq 0. \end{aligned} \quad (S3)$$

Proof S4 Proof of Eq. (29)

BR function (29) of the radar has three properties of the standard function for all $\mathbf{p}_R > 0$ and $\mathbf{p}_J > 0$:

(1) Positivity. For any $p_{R(kl)} > 0$ and $p_{J(jk)} > 0$, we have $\text{BR}_R(p_{J(jk)}) > 0$.

(2) Monotonicity. If $p_{J(jk)} \leq p'_{J(jk)}$, then

$$\text{BR}_R(p_{J(jk)}) - \text{BR}_R(p'_{J(jk)}) = \frac{\gamma_{R(kl)}^{\min} \left| \mathbf{w}_{r(kl)}^H \hat{\mathbf{c}}_{t(jk)} \right|^2}{\left| \mathbf{w}_{r(kl)}^H \hat{\mathbf{h}}_{t(kkl)} \right|^2} (p_{J(jk)} - p'_{J(jk)}) \leq 0. \quad (\text{S4})$$

(3) Scalability. For all $a > 1$, we have

$$a\text{BR}_R(p_{J(jk)}) - \text{BR}_R(ap_{J(jk)}) = (a - 1) \frac{\gamma_{R(kl)}^{\min} \hat{\eta}_{R(kl)}}{\left| \mathbf{w}_{r(kl)}^H \hat{\mathbf{h}}_{t(kkl)} \right|^2} > 0. \quad (\text{S5})$$