Interference-Assisted Secret Communication

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***Abstract*— Wireless communication is susceptible to adversarial eavesdropping due to the broadcast nature of the wireless medium. In this paper it is shown how eavesdropping can be alleviated by exploiting the superposition property of the wireless medium. A wiretap channel with a helping interferer (WT-HI), in which a transmitter sends a confidential message to its intended receiver in the presence of a passive eavesdropper, and with the help of an independent interferer, is considered. The interferer, which does not know the confidential message, helps in ensuring the secrecy of the message by sending independent signals. An achievable secrecy rate for the WT-HI is given. The results show that interference can be exploited to assist secrecy in wireless communications. An important example of the Gaussian case, in which the interferer has a better channel to the intended receiver than to the eavesdropper, is considered. In this situation, the interferer can send a (random) codeword at a rate that ensures that it can be decoded and subtracted from the received signal by the intended receiver but cannot be decoded by the eavesdropper. Hence, only the eavesdropper is interfered with and the secrecy level of the confidential message is increased.**

I. Introduction

Broadcast and superposition are two fundamental properties of the wireless medium. Due to the broadcast nature, wireless transmission can be received by multiple receivers with possibly different signal strengths. Due to the superposition property, a receiver observes a signal that is a superposition of multiple simultaneous transmissions. From the *secure communication* point of view, both features pose a number of security issues. In particular, the broadcast nature makes wireless transmission susceptible to *eavesdropping*, because anyone (including adversarial users) within the communication range can listen and possibly extract the confidential information. The superposition property makes wireless communication susceptible to *jamming* attacks, where adversarial users can superpose destructive signals (interference) onto useful signals to block the intended transmission.

A helper can pit one property of the wireless medium against the security issues caused by the other. An example in which broadcast is employed to counteract the effects of superposition is the case of a helper that functions as a relay to facilitate the transmission from a source terminal to a severely jammed destination terminal. In this paper, we consider the case in which a helper functions as an *interferer* to improve the secrecy level of a communication session which is compromised by a passive eavesdropper. This is an example where superposition is employed to counteract the security threat due to the broadcast nature of the wireless medium.

We study the problem in which a transmitter sends confidential messages to an intended receiver with the help of an interferer, in the presence of a passive eavesdropper. We call this model the *wiretap channel with a helping interferer* (WT-HI for brevity). In this system, it is desirable to minimize the leakage of information to the eavesdropper. The interferer tries to help by transmitting a signal without knowledge of the actual confidential message. The level of ignorance of the eavesdropper with respect to the confidential messages is measured by the equivocation rate. This information-theoretic approach was introduced by Wyner for the *wiretap channel* [1], in which a single source-destination communication is eavesdropped upon via a degraded channel. Wyner's formulation was generalized by Csiszár and Körner who determined the capacity region of the broadcast channel with confidential messages [2]. The Gaussian wiretap channel was considered in [3]. More recently, there has been a resurgence of interest in *information-theoretic security* for multi-user channel models. Related prior work includes the multiple access channel (MAC) with confidential messages [4]–[8], the interference channel with confidential messages [9], [10], and the relay-eavesdropper channel [11], [12].

In this paper, an achievable secrecy rate for the WT-HI under the requirement of *perfect secrecy* is given. That is, the eavesdropper is kept in total ignorance with respect to the message for the intended receiver. A geometrical interpretation of the achievable secrecy rate is given based on the MAC achievable rate regions from the transmitter and the interferer to the intended receiver and to the eavesdropper, respectively. For a symmetric Gaussian WT-HI, both the achievable secrecy rate and a power control scheme are given. The results show that the interferer can increase the secrecy level, and that a positive secrecy rate can be achieved even when the source-destination channel is worse than the source-eavesdropper channel. An important example of the Gaussian case is that in which the interferer has a better channel to the intended receiver than to the eavesdropper. Here, the interferer can send a (random) codeword at a rate that ensures that it can be decoded and subtracted from the received signal by the intended receiver, but cannot be decoded by the eavesdropper. Hence, only the eavesdropper is interfered with and the secrecy level of the confidential message can be increased. Our scheme can be considered to be a generalization of the two schemes

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in [8], [9], and [11]. In the cooperative jamming [8] (artificial noise [9]) scheme, the helper generates an independent Gaussian noise. This scheme does not employ any structure in the transmitted signal. The noise forwarding scheme in [11] requires that the interferer's codewords can always be decoded by the intended receiver, which is not necessary in our scheme.

The remainder of the paper is organized as follows. Section II describes the system model for the WT-HI. Section III states an achievable secrecy rate followed by its geometrical interpretations in Section IV. Section V gives the achievable secrecy rate and a power control scheme for a symmetric Gaussian WT-HI. Section VI illustrates the results through some numerical examples. Conclusions are given in Section VII.

II. System Model

We consider a communication system including a transmitter (X_1), an intended receiver (Y_1), a helping interferer (X_2), and a passive eavesdropper (Y_2). The transmitter sends a confidential message W to the intended receiver with the help from an *independent* interferer, in the presence of a passive but *intelligent* eavesdropper. We assume that the helper does not know the confidential message W and the eavesdropper knows codebooks of the transmitter and helper. As noted above, we refer to this channel as the wiretap channel with a helping-interferer (WT-HI). The channel can be defined by the alphabets $\mathcal{X}_1$, $\mathcal{X}_2$, $\mathcal{Y}_1$, $\mathcal{Y}_2$, and channel transition probability $p(y_1, y_2|x_1, x_2)$ where $x_t \in \mathcal{X}_t$ and $y_t \in \mathcal{Y}_t$, $t = 1, 2$.

The transmitter uses encoder 1 to encode a confidential message $w \in \mathcal{W} = \{1, \ldots, M\}$ into x_1^n and sends it to the intended receiver in n channel uses. A stochastic encoder [2] f is specified by a matrix of conditional probabilities $f(x_{1,k}|w)$, where $x_{1,k} \in \mathcal{X}_1$, $w \in \mathcal{W}$, $\sum_{x_{1,k}} f_1(x_{1,k}|w) = 1$ for all $k = 1, \ldots, n$, and $f(x_{1,k}|w)$ is the probability that encoder 1 outputs $x_{1,k}$ when message w is being sent. The helper generates its output $x_{2,k}$ randomly and can be considered as using another stochastic encoder f_2, which is specified by a matrix of probabilities $f_2(x_{2,k})$ with $x_{2,k} \in \mathcal{X}_2$ and $\sum_{x_{2,k}} f_2(x_{2,k}) = 1$. Since randomization can increase secrecy, encoder 1 uses stochastic encoding to introduce *randomness*. Additional randomization is provided by the helper and the secrecy can be increased further.

The decoder uses the output sequence y_1^n to compute its estimate $\hat{w}$ of w. The decoding function is specified by a (deterministic) mapping $g : \mathcal{Y}_1^n \to \mathcal{W}$.

The average probability of error is

$$P_e = \frac{1}{M} \sum_{w} \Pr\left\{g(Y_1^n) \neq w | w \text{ sent}\right\}. \tag{1}$$

The secrecy level (level of ignorance of the eavesdropper with respect to the confidential message w) is measured by the equivocation rate $(1/n)H(W|Y_2^n)$.

A secrecy rate R_s is achievable for the WT-HI if, for any $\epsilon > 0$, there exists an (M, n, P_e) code so that

$$M \geq 2^{nR_s},\ P_e \leq \epsilon \tag{2}$$

$$\text{and} \qquad R_s - \frac{1}{n} H(W|Z^n) \leq \epsilon \tag{3}$$

for all sufficiently large n. The secrecy capacity is the maximal achievable secrecy rate.

III. Achievable Secrecy Rate

Theorem 1: Let $\mathcal{R}_1$ denote the achievable rate region of the MAC $(\mathcal{X}_1, \mathcal{X}_2) \to \mathcal{Y}_1$:

$$\mathcal{R}_1^{[\mathrm{MAC}]} = \left\{ (R_1, R_2) \;\middle|\; \begin{array}{l} R_1 \geq 0,\ R_2 \geq 0, \\ R_1 \leq I(X_1; Y_1|X_2), \\ R_2 \leq I(X_2; Y_1|X_1), \\ R_1 + R_2 \leq I(X_1, X_2; Y_1) \end{array} \right\} \tag{4}$$

and $\mathcal{R}_2$ denote the region of the MAC $(\mathcal{X}_1, \mathcal{X}_2) \to \mathcal{Y}_2$:

$$\mathcal{R}_2^{[\mathrm{MAC}]} = \left\{ (R_1, R_2) \;\middle|\; \begin{array}{l} R_1 \geq 0,\ R_2 \geq 0, \\ R_1 < I(X_1; Y_2|X_2), \\ R_2 < I(X_2; Y_2|X_1), \\ R_1 + R_2 < I(X_1, X_2; Y_2) \end{array} \right\}. \tag{5}$$

We also define

$$\mathcal{R}_1^{[\mathrm{S}]} = \left\{ (R_1, R_2) \;\middle|\; \begin{array}{l} R_1 \geq 0,\ R_2 \geq 0, \\ R_1 \leq I(X_1; Y_1), \\ R_2 > I(X_2; Y_1|X_1) \end{array} \right\} \tag{6}$$

$$\text{and} \quad \mathcal{R}_2^{[\mathrm{S}]} = \left\{ (R_1, R_2) \;\middle|\; \begin{array}{l} R_1 \geq 0,\ R_2 \geq 0, \\ R_1 < I(X_1; Y_2), \\ R_2 > I(X_2; Y_2|X_1) \end{array} \right\}. \tag{7}$$

The following secrecy rate is achievable for the WT-HI:

$$R_s = \max_{\pi, R_1, R_2, R_{1,d}} \left\{ R_{1,s} \;\middle|\; \begin{array}{l} R_{1,s} + R_{1,d} = R_1, \\ (R_1, R_2) \in \left\{ \mathcal{R}_1^{[\mathrm{MAC}]} \cup \mathcal{R}_1^{[\mathrm{S}]} \right\}, \\ (R_{1,d}, R_2) \notin \left\{ \mathcal{R}_2^{[\mathrm{MAC}]} \cup \mathcal{R}_2^{[\mathrm{S}]} \right\} \end{array} \right\}, \tag{8}$$

where π is the class of distributions that factor as

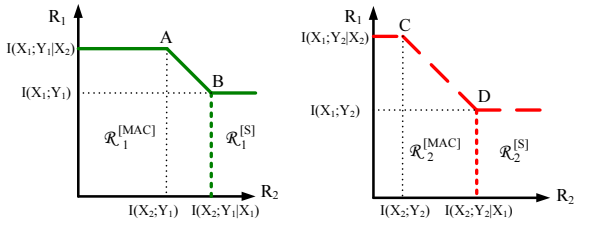
$$p(x_1)p(x_2)p(y_1, y_2|x_1, x_2). \tag{9}$$

Proof: We briefly outline the achievable coding scheme here and omit the details of the proof, which can be found in [13]. We consider two independent stochastic codebooks. Encoder 1 uses codebook $\mathcal{C}_1(2^{nR_1}, 2^{nR_{1,s}}, n)$, where n is the codeword length, 2^{nR_1} is the size of the codebook, and $2^{nR_{1,s}}$ is the number of confidential messages that $\mathcal{C}_1$ can convey ($R_{1,s} \leq R$). In addition, encoder 2 uses codebook $\mathcal{C}_2(2^{nR_2}, n)$, where 2^{nR_2} is the codebook size. The 2^{nR_1} codewords in codebook $\mathcal{C}_1$ are randomly grouped into $2^{nR_{1,s}}$ bins each with $M = 2^{n(R_1 - R_{1,s})}$ codewords. During the encoding, to send message $w \in [1, \ldots, 2^{nR_{1,s}}]$, encoder 1 randomly selects a codeword from bin w and sends to channel, while encoder 2 randomly selects a codeword from codebook $\mathcal{C}_2$ to transmit. ■

Remark 1: The rate R_1 is split as $R_1 = R_{1,s} + R_{1,d}$, where $R_{1,s}$ denotes a secrecy information rate intended by receiver 1 and $R_{1,d}$ represent a redundancy rate sacrificed in order to confuse the eavesdropper. The interferer helps the receiver 1 confuse the eavesdropper by transmitting dummy information with rate R_2.

IV. Geometric Interpretations

When the intended receiver needs to decode both codewords from $\mathcal{C}_1$ and $\mathcal{C}_2$, we essentially have a compound MAC. However, the receiver cares about only $\mathcal{C}_1$ and does not need



(a) intended receiver (b) eavesdropper

Fig. 1. Code rate R_1 versus R_2 for the intended receiver and eavesdropper.

to decode $\mathcal{C}_2$. Hence, as shown in Fig. 1, the "achievable" rate region in the R_1-R_2 plane at the receiver is the union of $\mathcal{R}_1^{[\mathrm{MAC}]}$ and $\mathcal{R}_1^{[\mathrm{S}]}$. Here $\mathcal{R}_1^{[\mathrm{MAC}]}$ is the capacity region of the MAC $(\mathcal{X}_1, \mathcal{X}_2) \to \mathcal{Y}_1$, in which the intended receiver can decode both $\mathcal{C}_1$ and $\mathcal{C}_2$, while $\mathcal{R}_1^{[\mathrm{S}]}$ is the region in which the receiver treats codewords from X_2 as noise and decodes $\mathcal{C}_1$ only. Similar analysis applies for the eavesdropper as shown in Fig. 1.b. We note that a proper choice of the redundancy rate R_2 can put the eavesdropper in its unfavorable condition, which can increase secrecy. In the following, we consider three typical cases: very strong interference, strong interference, and weak interference. The analysis for general cases can be found in [13].

A. Very Strong Interference

Fig. 2 illustrates the interference channel with very strong interference. In this case, since

$$I(X_1; Y_2) \geq I(X_1; Y_1|X_2), \tag{10}$$

we cannot obtain any positive secrecy rate.

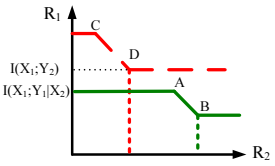


Fig. 2. Very strong interference channel

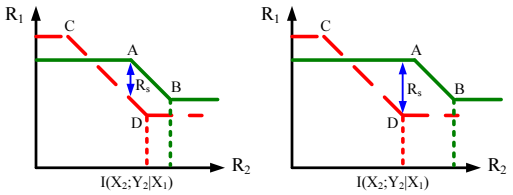
B. Strong Interference

We consider strong interference, i.e.,

$$\begin{aligned} & I(X_1; Y_1|X_2) \leq I(X_1; Y_2|X_2) \\ \text{and} \quad & I(X_2; Y_2|X_1) \leq I(X_2; Y_1|X_1) \end{aligned} \tag{11}$$

for all product distributions on the input X_1 and X_2. This condition implies that, without the interferer, channel $\mathcal{X}_1 \to \mathcal{Y}_2$ is more capable than channel $\mathcal{X}_1 \to \mathcal{Y}_1$ and, hence, the achievable secrecy rate may be 0.

However, as shown in Fig. 3, we may achieve a positive secrecy rate with the help of the interferer. Here we choose the rate pair $(R_1, R_2) \in \mathcal{R}_1^{[\mathrm{MAC}]}$ so that the intended receiver



(a) $I(X_2; Y_1) \leq I(X_2; Y_2|X_1)$ (b) $I(X_2; Y_1) > I(X_2; Y_2|X_1)$

Fig. 3. Strong interference channel and $I(X_1, X_2; Y_1) > I(X_1, X_2; Y_2)$

can first decode $\mathcal{C}_2$ and then $\mathcal{C}_1$. Moreover, the dummy rate pair satisfies

$$(R_{1,d}, R_2) \notin \left\{ \mathcal{R}_2^{[\mathrm{MAC}]} \cup \mathcal{R}_2^{[\mathrm{S}]} \right\},$$

i.e., we provide enough randomness to confuse the eavesdropper. Hence, for strong interference, the achievable secrecy rate can be simplified as

$$R_s = \max_{\pi} \left\{ \min \begin{bmatrix} I(X_1, X_2; Y_1) - I(X_1, X_2; Y_2), \\ I(X_1; Y_1|X_2) - I(X_1; Y_2) \end{bmatrix} \right\}^+.$$

C. Weak Interference

Weak interference implies that

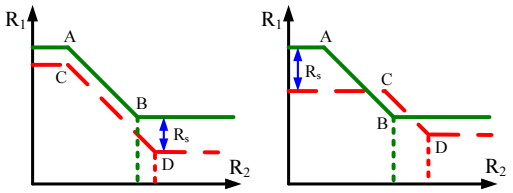
$$\begin{aligned} & I(X_1; Y_1|X_2) \geq I(X_1; Y_2|X_2) \\ \text{and} \quad & I(X_2; Y_2|X_1) \geq I(X_2; Y_1|X_1) \end{aligned} \tag{12}$$

for all product distributions on the input X_1 and X_2. Let

$$\Delta_1 = I(X_1; Y_1|X_2) - I(X_1; Y_2|X_2) \tag{13}$$

$$\text{and} \quad \Delta_2 = I(X_1; Y_1) - I(X_1; Y_2). \tag{14}$$

As shown in Fig. 4.a, the achievable secrecy can be increased by the help from the interferer when $\Delta_1 \leq \Delta_2$. In this



(a) $\Delta_1 \leq \Delta_2$ (b) $\Delta_1 > \Delta_2$

Fig. 4. Weak interference channel

case, the interferer generates an "artificial noise" with the dummy rate $R_2 > I(X_2; Y_2|X_1)$ so that neither the receiver nor the eavesdropper can decode $\mathcal{C}_2$. On the other hand, when $\Delta_1 > \Delta_2$, the interferer "facilitates" the transmitter by properly choosing the signal X_2 to maximize Δ_1. In the case of weak interference, the achievable secrecy rate can be summarized as

$$R_s = \max_{\pi} \left\{ \max \left(\Delta_1, \Delta_2 \right) \right\}.$$

V. Symmetric Gaussian Channels

In this section, we consider the Gaussian wiretap channel with a helping interferer (GWT-HI). In order to introduce the results in the simplest possible setting, in this paper we focus on a symmetric Gaussian channel as illustrated in Fig. 5, where the source-eavesdropper and interferer-receiver channels have the same channel condition. The results for the GWT-HI with general parameter settings can be found in [13].

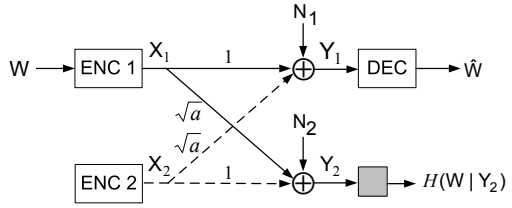


Fig. 5. A symmetric Gaussian wiretap channel with a helping interferer.

The channel outputs at the intended receiver and the eavesdropper can be written as

$$\begin{aligned} Y_{1,k} &= X_{1,k} + \sqrt{a}X_{2,k} + N_{1,k}, \\ Y_{2,k} &= \sqrt{a}X_{1,k} + X_{2,k} + N_{2,k}, \end{aligned} \tag{15}$$

for $k = 1, \ldots, n$, where $N_{1,k}$ and $N_{2,k}$ are sequences of independent and identically distributed zero-mean Gaussian noise variables with unit variances. The channel inputs $X_{1,k}$ and $X_{2,k}$ satisfy average block power constraints of the form

$$\frac{1}{n}\sum_{k=1}^{n} E[X_{1,k}^2] \le \bar{P}_1, \quad \frac{1}{n}\sum_{k=1}^{n} E[X_{2,k}^2] \le \bar{P}_2, \tag{16}$$

A. Achievable Secrecy Rate

We give an achievable secrecy rate by assuming that both encoders use Gaussian codebooks. In this subsection, we assume that the codewords in $\mathcal{C}_1$ and $\mathcal{C}_2$ have average block powers P_1 and P_2, respectively. The optimal P_1 and P_2 satisfying the requirements of $P_1 \le \bar{P}_1$ and $P_2 \le \bar{P}_2$ are found in Subsection V-B.

Theorem 2: For the symmetric Gaussian wiretap channel with a helping interferer given by (15),

i) if $a \ge 1 + P_2$, the achievable secrecy rate is $R_s = 0$;

ii) if $1 \le a < 1 + P_2$, the achievable secrecy rate is

$$R_s(P_1, P_2) = \begin{cases} \mathrm{g}(P_1) - \mathrm{g}(\frac{aP_1}{1+P_2}) & \text{if } P_1 < P_2,\ a > 1 + P_1, \\ \mathrm{g}(P_1 + aP_2) - \mathrm{g}(aP_1 + P_2) & \text{if } P_1 < P_2,\ a \le 1 + P_1, \\ 0 & \text{otherwise;} \end{cases}$$

iii) if $a < 1$, the achievable secrecy rate is

$$R_s(P_1, P_2) = \begin{cases} \mathrm{g}(\frac{P_1}{1+aP_2}) - \mathrm{g}(\frac{aP_1}{1+P_2}) & \text{if } P_1 > P_2, \\ \mathrm{g}(P_1) - g(aP_1) & \text{otherwise,} \end{cases}$$

where $\mathrm{g}(x) = (1/2)\log_2(1 + x)$.

Proof: We use the achievability scheme in Theorem 1 with Gaussian input distributions. ■

Remark 2: For comparison, we recall that the secrecy capacity of the Gaussian wiretap channel [3] (the case without an interferer in the GWT-HI model) is

$$R_s^{\mathrm{WT}}(P_1) = \begin{cases} \mathrm{g}(P_1) - \mathrm{g}(aP_1) & \text{if } a < 1, \\ 0 & \text{if } a \ge 1. \end{cases} \tag{17}$$

That is, a positive secrecy rate can be achieved for the wiretap channel only when $a < 1$. According to Theorem 2, a positive secrecy rate can be achieved for the symmetric GWT-HI when $a < 1 + P_2$. If the interferer has sufficiently large power, a positive secrecy rate can be achieved for any $a > 0$.

Remark 3: $a \ge 1 + P_2$, $1 \le a < 1 + P_2$, and $a < 1$ fall into the cases of very strong interference, strong interference and weak interference, respectively.

B. Power Control

Power control is essential to interference management for accommodating multi-user communications. As for the GWT-HI, power control also plays a critical role. In this subsection, we consider the optimal power control strategy for increasing the secrecy rate given in Theorem 2.

Theorem 3: When $a \ge 1$, the power control scheme for maximizing the secrecy rate is given by

$$(P_1, P_2) = \begin{cases} \left(\min\{\bar{P}_1, P_1^*\}, \bar{P}_2\right) & \text{if } \bar{P}_2 > a - 1, \\ (0, 0) & \text{otherwise,} \end{cases} \tag{18}$$

where $P_1^* = a - 1$.

When $a < 1$, the power control scheme for maximizing the secrecy rate is given by

$$(P_1, P_2) = \left(\bar{P}_1, \min\{\bar{P}_2, P_2^*\}\right), \tag{19}$$

where

$$P_2^* = \frac{\sqrt{1 + (1+a)\bar{P}_1} - 1}{1 + a}. \tag{20}$$

Proof: The proof can be found in [13]. ■

Remark 4: When $a < 1$, the interferer controls its power so that it does not bring too much interference to the primary transmission. When $a \ge 1$, the benefits of power control at the transmitter are two-fold: First, less information is leaked to the eavesdropper; and furthermore, the intended receiver can successfully decode (and cancel) the interference.

C. Power-Unconstrained Secrecy Rate

A fundamental parameter of wiretap-channel-based wireless secrecy systems is the achievable secrecy rate when the transmitter has unconstrained power. This secrecy rate is related only to the channel conditions, and is the maximal achievable secrecy rate no matter how large the transmit power is. For example, the power-unconstrained secrecy rate for a Gaussian wiretap channel (when there is no interferer in the GWT-HI model) is given by

$$\lim_{\bar{P}_1 \to \infty} R_s^{\mathrm{WT}}(\bar{P}_1) = \lim_{\bar{P}_1 \to \infty} \left[\mathrm{g}(\bar{P}_1) - \mathrm{g}(a\bar{P}_1)\right]^+ = \frac{1}{2}\left[\log_2 \frac{1}{a}\right]^+. \tag{21}$$

After some limiting analysis, we have the following result for the symmetric GWT-HI model.

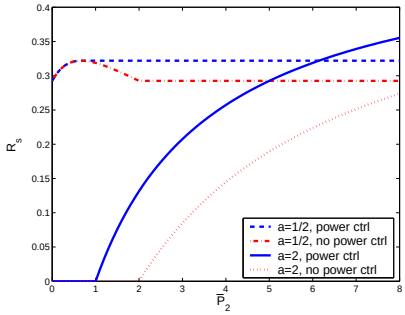


Fig. 6. Secrecy rate R_s versus $\bar{P}_2$, where $\bar{P}_1 = 2$.

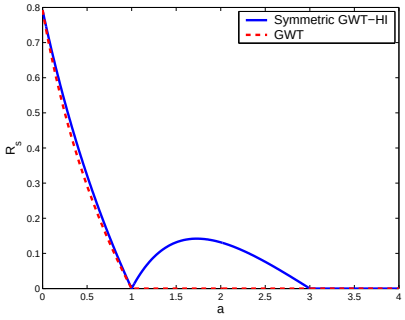


Fig. 7. Secrecy rate R_s versus a, where $\bar{P}_1 = \bar{P}_2 = 2$.

Theorem 4: The achievable power-unconstrained secrecy rate for the symmetric GWT-HI is

$$\lim_{\bar{P}_1,\bar{P}_2\to\infty} R_s = \begin{cases} \frac{1}{2}\log_2 a & \text{if } a \geq 1, \\ \log_2 \frac{1}{a} & \text{if } a < 1. \end{cases} \quad (22)$$

Proof: The proof can be found in [13]. ■

When the interference is strong ($a > 1$), the power unconstrained secrecy rate is $(1/2)\log_2 a$. Note that $(1/2)\log_2 a$ is the power-unconstrained secrecy rate if confidential messages are sent from the interferer to the intended receiver in the presence of the eavesdropper. This is particularly interesting because we do not even assume that there is a source-interferer channel (which enables the interferer to relay the transmission). When the interference is weak ($a < 1$), the interferer assists the secret transmission by doubling the achievable secrecy rate.

VI. Numerical Examples

In Fig. 6, we present a numerical example to show the benefits of the power control scheme to the secrecy rate R_s. In this example, we assume that the source power constraint is $\bar{P}_1 = 2$, and the interferer power constraint $\bar{P}_2$ varies from 0 to 8. We can see that the power control scheme can increase the secrecy rate significantly. When $a = 2$, the power control scheme uses the maximum interferer power and holds the source power to be $P_1^* = 1$, so that the intended receiver can decode the interference first. When $a = 1/2$, the power control scheme uses the maximum source power and holds the interferer power below $P_2^* = 2/3$, so that the interferer does not introduce too much interference to the intended receiver (which treats the interference as noise in this case).

In Fig. 7, we present another example to show the achievable secrecy rate R_s for different values of a. In this example, we assume that $\bar{P}_1 = \bar{P}_2 = 2$, and a varies from 0 to 4. Comparing the secrecy rates achievable for the GWT-HI and GWT, we find that an independent interferer increases R_s. For the GWT, R_s decreases with a and remain 0 when $a \geq 1$. For the GWT-HI, R_s first decreases with a when $a < 1$; when $1 < a \leq 1.73$, R_s increases with a because the intended receiver now can decode and cancel the interference, while the eavesdropper can only treats the interference as noise; when $a > 1.73$, R_s decreases again with a because the interference does not hurt the eavesdropper much when a is large. In particular, when $a \geq 3 (= 1 + \bar{P}_2)$, the eavesdropper can fully decode the primary transmission by treating the interference as noise. Therefore, $R_s = 0$ when $a \geq 3$.

VII. Conclusions

In this paper, we have considered the use of the superposition property of the wireless medium to alleviate the eavesdropping issues caused by the broadcast nature of the medium. We have studied a wiretap channel with a helping interferer, in which the interferer assists the secret communication by injecting independent interference. We have given an achievable secrecy rate with its geometrical interpretation. The results show that interference can be exploited to benefit secret wireless communication.

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