Appendix A
Proof of Lemma 1

$$I_{pp} = \sum_{x_i^p \in \Phi_p^1 \setminus x_k^p} P_p h_X ||y_i^p||^{-\alpha}$$

$$\mathcal{L}_{I_{pp}}(s) = E\left\{ \exp\left(- s \sum_{x_i^p \in \Phi_p^1 \setminus x_k^p} P_p h_X ||y_i^p||^{-\alpha} \right) \right\}$$

$$= E_{\Phi}\left\{ \prod_{x_i^p \in \Phi_p^1} E_{h_X}\left(\exp(-sP_p h_X ||y_i^p||^{-\alpha}) \right) \right\}$$

$$\overset{(a)}{=} E_{\Phi}\left\{ \prod_{x_i^p \in \Phi_p^1} \frac{1}{1 + sP_p ||y_i^p||^{-\alpha}} \right\}$$

$$\overset{(b)}{=} \exp\left\{ -2\pi\lambda_p^1 \int_0^{\infty} \frac{r}{1 + \frac{r^{\alpha}}{sP_p}} dr \right\}$$

$$\overset{(c)}{=} \exp\left\{ -\pi \frac{\gamma \lambda_p^1 (sP_p)^{\frac{\gamma}{\pi}}}{\sin(\gamma)} \right\}$$

(a) follows after Rayleigh fading assumption and (b) is obtained after applying PGFL of PPP in polar coordinate form. Solving the integral and making $\gamma = \frac{2\pi}{\alpha}$, (c) is obtained. This completes the proof.

Appendix B
Proof of Lemma 5

$$I_{sp} = \sum_{x_i^s \in \Phi_s \cap \Xi_R^c \cap \Xi_d^c} P_s h_x ||y_i^p||^{-\alpha}$$

$$\mathcal{L}_{I_{sp}}(s) = E\left\{ \exp\left(- s \sum_{x_i^s \in \Phi_s \cap \Xi_R^c \cap \Xi_d^c} P_s h_x ||y_i^p||^{-\alpha} \right) \right\}$$

$$\overset{(a)}{=} \exp\left\{ -\lambda_s \int_{R^2 \setminus \Xi_R} \frac{1}{1 + \frac{||y||^{\alpha}}{sP_s}} dy \right\} \exp\left\{ \lambda_s \int_{\Xi_d} \frac{1}{1 + \frac{||y||^{\alpha}}{sP_s}} dy \right\}$$

Note that our interest is in obtaining interference from SUs in the space except SUs located inside any disk $b(y_i^s, d)$, where $y_i^s (i = 1, ...n)$ is a typical active secondary receiver assumed to be located at the origin of a disk of radius d. Since interfering SUs cannot be located inside active PUs' exclusion region, the idea is to capture interference generated outside all disks $b(y_i^p, R)$ and $b(y_i^s, d)$, bearing in mind that there may be overlap of protection regions. To do this, we refer to Fig. 1. The first part of (a) gives

$$\overset{(b)}{=} \exp\left\{ -\pi \frac{\gamma \lambda_s (sP_s)^{\frac{\gamma}{\pi}}}{\sin(\gamma)} \right\} \times$$

$$\exp\left\{ \lambda_s \prod_{x_i^p \in \Phi_p^1} \int \int_{r,\theta \in b(y,R)} \frac{r}{1 + \frac{r^{\alpha}}{sP_s}} dr d\theta \right\}$$

(b) involves application of PGFL of PPP in polar coordinate form. From Fig. 1, each PU has a circle centered at its primary receiver with protection region R denoted as $b(y_i^p, R)$. Hence, r should be bounded in the range $v - R \leq r \leq v + R$ and for every r within that range, θ should be bounded in

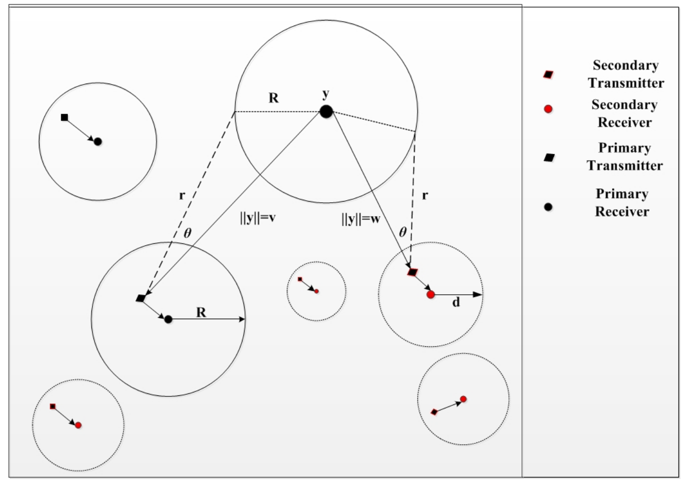

Fig. 1. Area of integration under PU with SU interference control

the range $-cos^{-1}\left(\frac{-D^2+v^2+r^2}{2vr}\right) \leq \theta \leq cos^{-1}\left(\frac{-D^2+v^2+r^2}{2vr}\right)$ following the cosine rule. Hence,

$$\exp\left\{ -\lambda_s \int_{R^2 \setminus \Xi_R} \frac{1}{1 + \frac{||y||^{\alpha}}{sP_s}} dy \right\} \leq \exp\left\{ -\pi \frac{\gamma \lambda_s (sP_s)^{\frac{\gamma}{\pi}}}{\sin(\gamma)} \right\}$$

$$\exp\left\{ -2\pi\lambda_p^1 \int_R^{\infty} \Big(1 - \exp(f(v))\Big) v dv \right\},$$

where $f(v) = \int_{v-R}^{v+R} cos^{-1}\left(\frac{-R^2+v^2+r^2}{2vr}\right) \frac{2\lambda_s r}{1+\frac{r^{\alpha}}{sP_s}} dr$. Now, we solve the second integral.

$$\int_{\Xi_d} \frac{1}{1 + \frac{||y||^{\alpha}}{sP_s}} dy = E_{\Phi_s^{11}}\left\{ \prod_{x_i^s \in \Phi_s^{11}} \int_{b(x_i^s, d)} \frac{1}{1 + \frac{||y||^{\alpha}}{sP_s}} \right\}$$

$$\overset{(c)}{\leq} E_{\Phi}\left\{ \prod_{x_i^s \in \Phi_s^{11}} \exp\left(2 \int_{w-d}^{w+d} \left(\frac{-d^2 + w^2 + r^2}{2wr} \right) \frac{r}{1 + \frac{r^{\alpha}}{sP_s}} dr \right\}$$

Hence,

$$\exp\left\{ \lambda_s \int_{\Xi_d} \frac{1}{1 + \frac{||y||^{\alpha}}{sP_s}} dy \right\} \overset{(d)}{\leq}$$

$$\exp\left\{ -2\pi\lambda_s^{11} \int_d^{\infty} \Big(1 - \exp(f(w))\Big) w dw \right\}.$$

(c) and (d) follow applying PGFL of PPP in polar coordinate form. Substituting the solutions of the first and second integrals back into (a) gives Lemma 5. This completes the proof.