Impact of the Secondary Network on the Outage Performance of the Primary Service in Spectrum Sharing

Mohammad G. Khoshkholgh, Keivan Navaie
Department of ECE
Tarbiat Modares University, Tehran, Iran
Email: keivan.navaie@ieee.org

Halim Yanikomeroglu
Department of SCE
Carleton University, Ottawa, Canada
Email: halim@sce.carleton.ca

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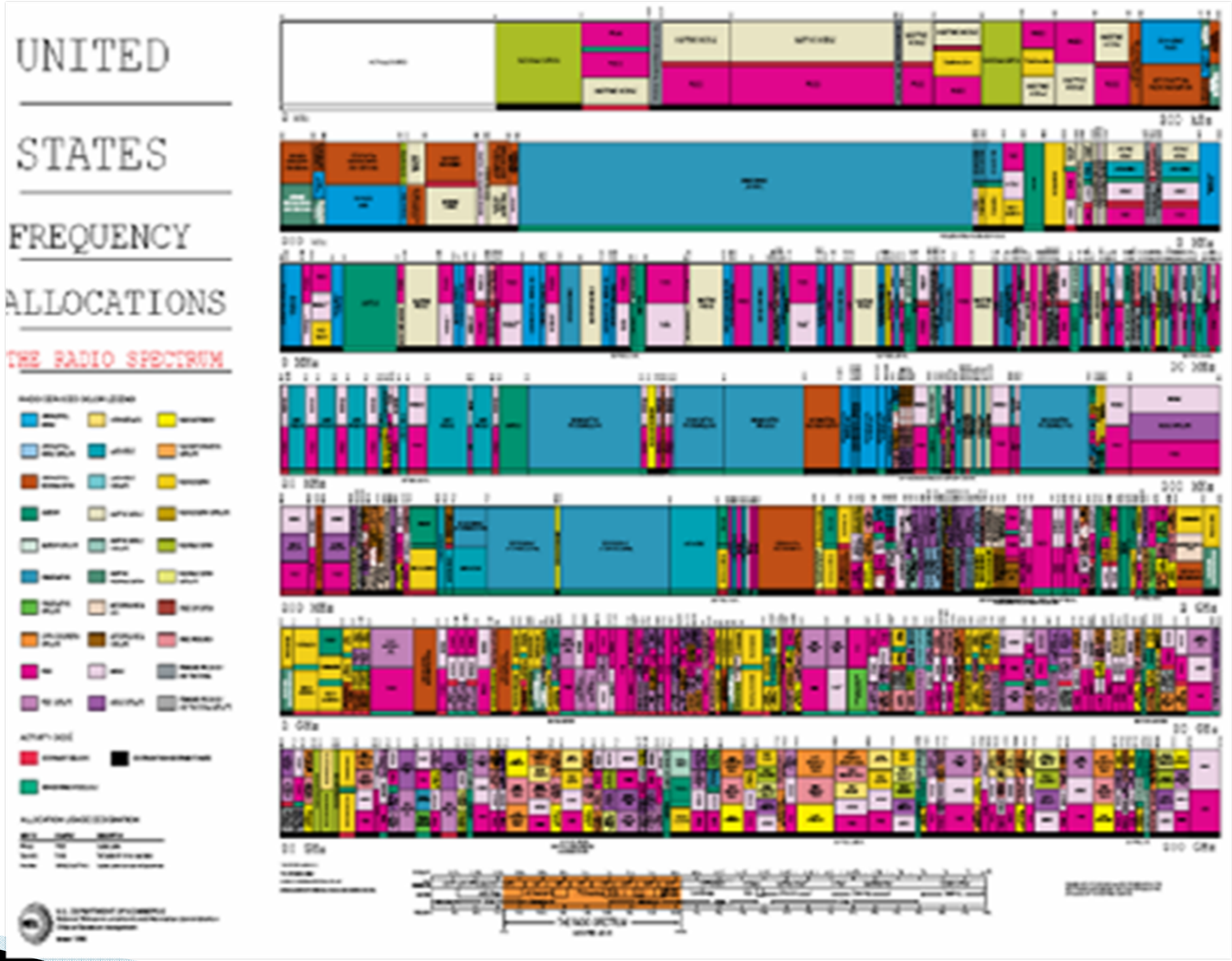
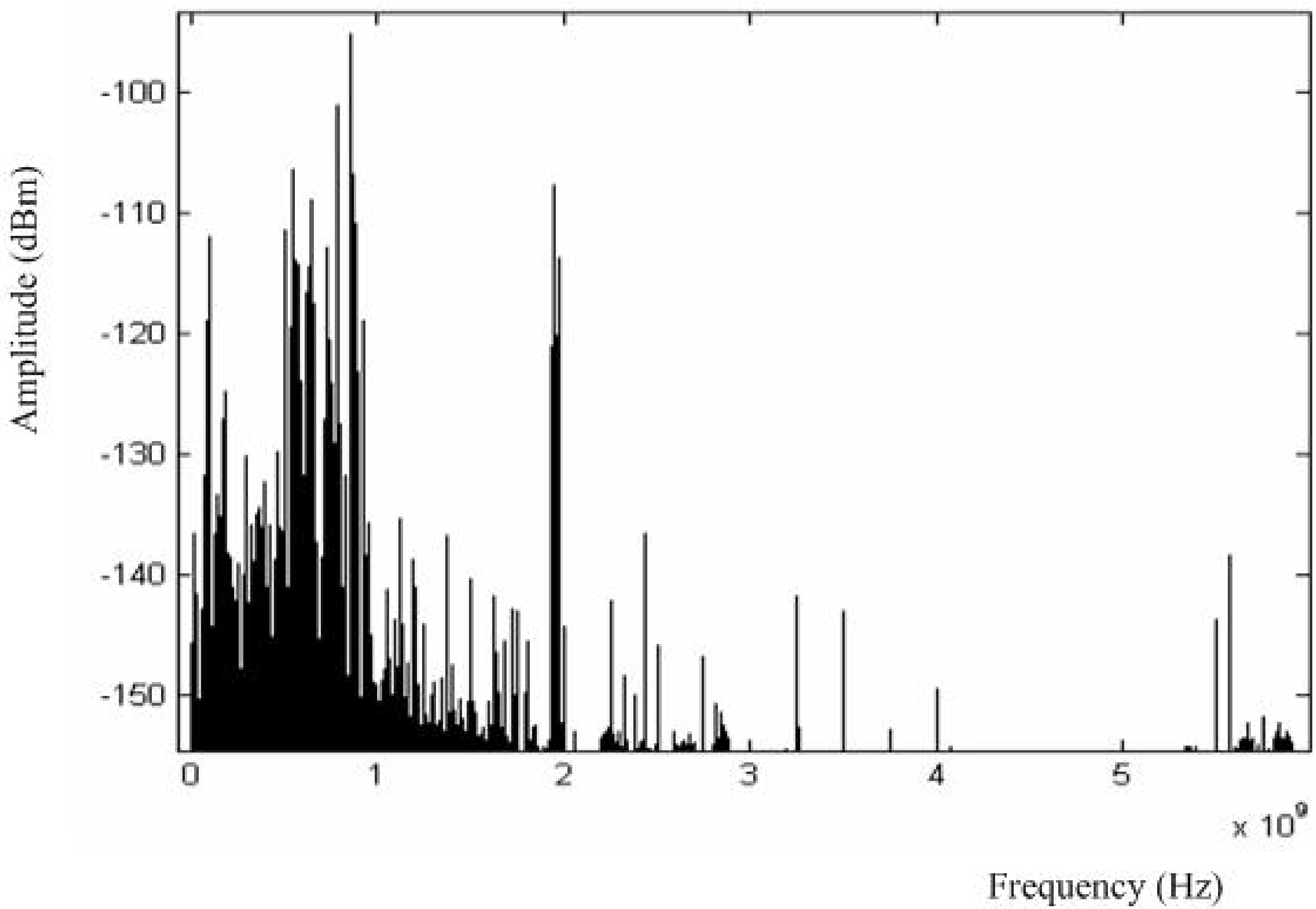
Spectrum Allocation Chart



Spectral Efficiency (in practice)



Spectrum Sharing

- Existing spectrum policy has full allocation but poor utilization
- Spectrum sharing proposed to improve spectral efficiency
- Primary service is the licensee
- Secondary service utilizes Opportunistic Spectrum Access (OSA)
- Secondary service detects and makes use of the spectrum holes/white spaces
- Interference threshold is defined as a metric to detect spectrum holes/white spaces

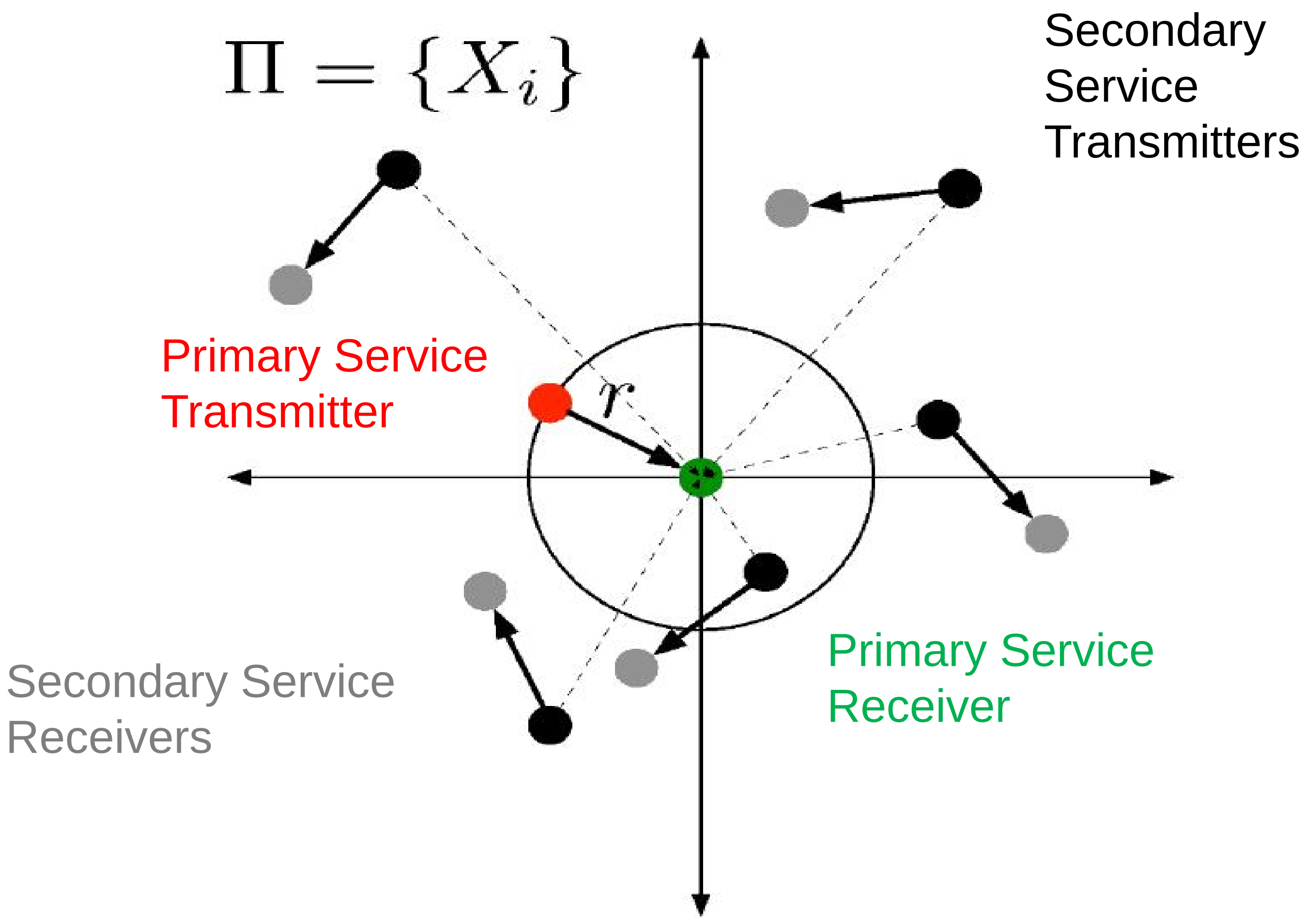
Spectrum Sharing: challenges

- To protect the primary service from unacceptable QoS degradation
  - access to the white spaces subject to no/minimum QoS degradation at the primary receiver
    - manage the imposed interference at the primary receiver to satisfy the interference threshold
- To improve the spectral efficiency
  - accommodate as much secondary service users as possible
    - utilize sophisticated power control mechanism
    - utilize accurate spectrum sensing procedure
    - . . .

Objective and Summary of Results

- To analyze the impacts of the secondary service parameters & the wireless environment on the primary service outage probability
  - a closed form is derived for the primary service outage probability derived based on the transmit power of the secondary service and miss detection probability of the spectrum sensing
  - the maximum secondary service transmitter node density is obtained for a given outage probability constraint of the primary service
  - an upper bound is obtained to the achievable capacity of the primary service

System Model



System Model (cont'd)

- The secondary service transmitters distributed based on a Homogenous Point Process

$$\Pr\{k\,SS\,in\ region\,R\} = e^{-\lambda_s A}\frac{(\lambda_s A)^k}{k!}$$

where A is area of region R.

If the spectrum is idle and the spectrum sensing wrongly recognize the spectrum status as busy, a false alarm is occurred.

- All secondary service transmitters have identical ROC curves, i.e., equal false alarm, ε, and miss detection probability δ

miss detection is occurred in cases where the spectrum is busy and it is mistakenly recognized as idle

System Model (cont'd)

- The channel is available with probability $p_i = 1 - p_b$
- The set of secondary users which experience miss detection

$$\tilde{\Pi} = \{ X_i \in \Pi \mid D_i = 1 (\text{miss detection indicator}) \}$$

with density $\lambda_s p_b \delta$

- Channel power gain between primary transceiver is exponentially distributed
- Channel power gain among secondary transmitters and the primary receiver are independent exponential random variables

Interference Aggregation

- Received interference at the primary receiver in miss detection experiences

$$I_{\varphi} = \sum_{i \in \prod} S_s \left\| X_i \right\|^{-\alpha} g_{sp,i}$$

S_s is the secondary service transmission power

$\left\| X_i \right\|^{-\alpha}$ is the distance-dependent path-loss attenuation

I_{φ} is a power law shot noise process

Goals & Analytical Tool

- Obtaining the primary service outage probability surrounding by a secondary network distributed based on Homogenous Point Process
- Obtain the maximum number of the secondary transmitters per unit area to satisfy the primary service outage probability constraint ξ
- Stochastic Geometry results are utilized for analysis

Primary Service Outage Probability

- Primary service SINR

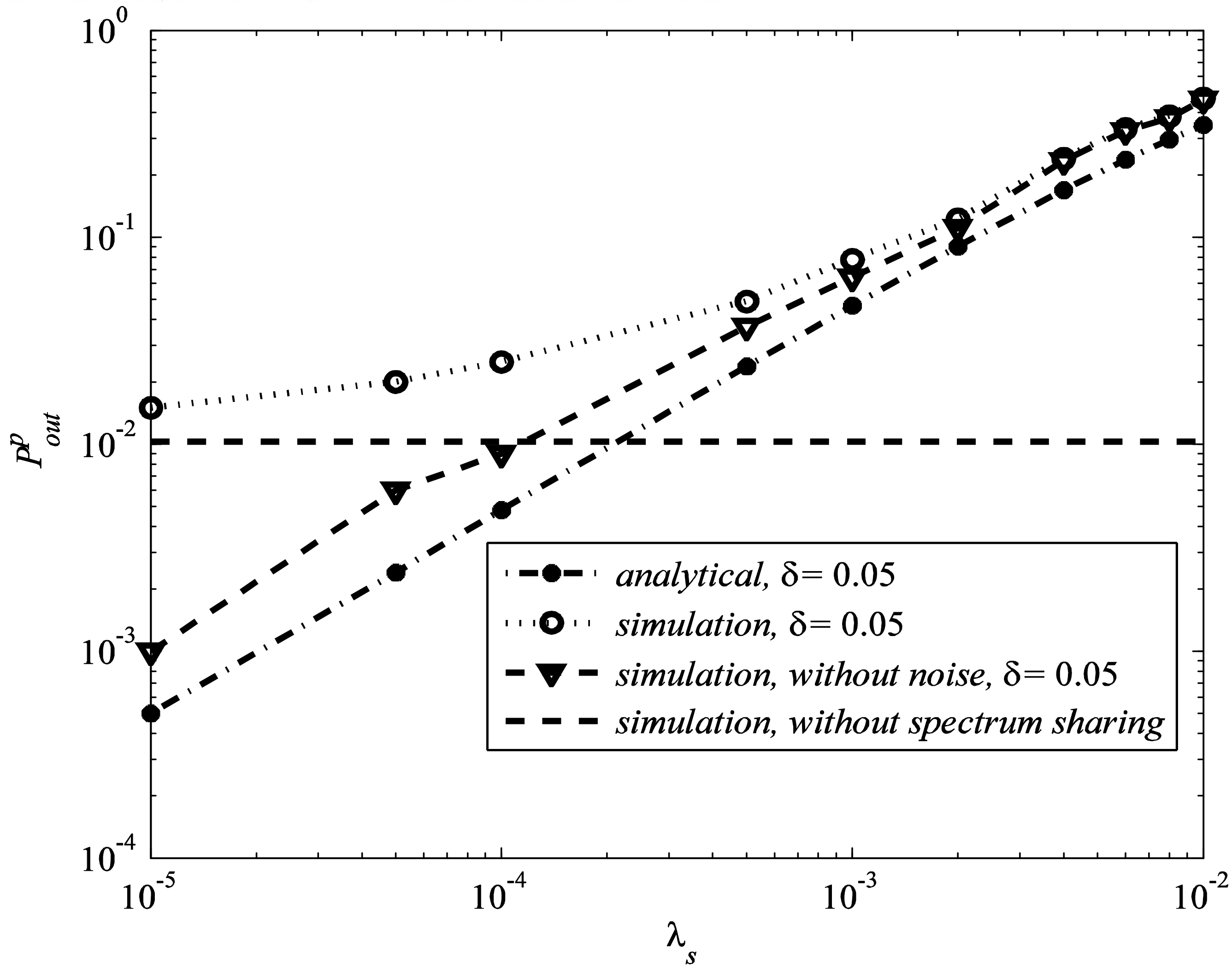
$$SINR_p = \frac{S_p R^{-\alpha} g_p}{W + I_\varphi}$$

- We show that the Primary service outage probability is

$$P_{out}^{p} = \Pr\left\{ SINR_p < \gamma_{th} \right\}$$

$$= 1 - \Phi_W\left(\mu \frac{\gamma_{th} R^{\alpha}}{S_p} \right) e^{-\lambda R^2 \left(\frac{S_s \gamma_{th}}{S_p} \right)^{\alpha/2} L(\alpha)}$$

Primary Service Outage Probability: Analysis and Simulations



Maximum Secondary Transmitter Density

- We show that the maximum secondary transmitter density for satisfying the primary service outage probability

$$\lambda_s^* = \left(\frac{S_s \gamma_{th}}{S_p} \right)^{-2/\alpha} \frac{\ln \frac{1}{1-\xi}}{R^2 L \delta p_b}$$

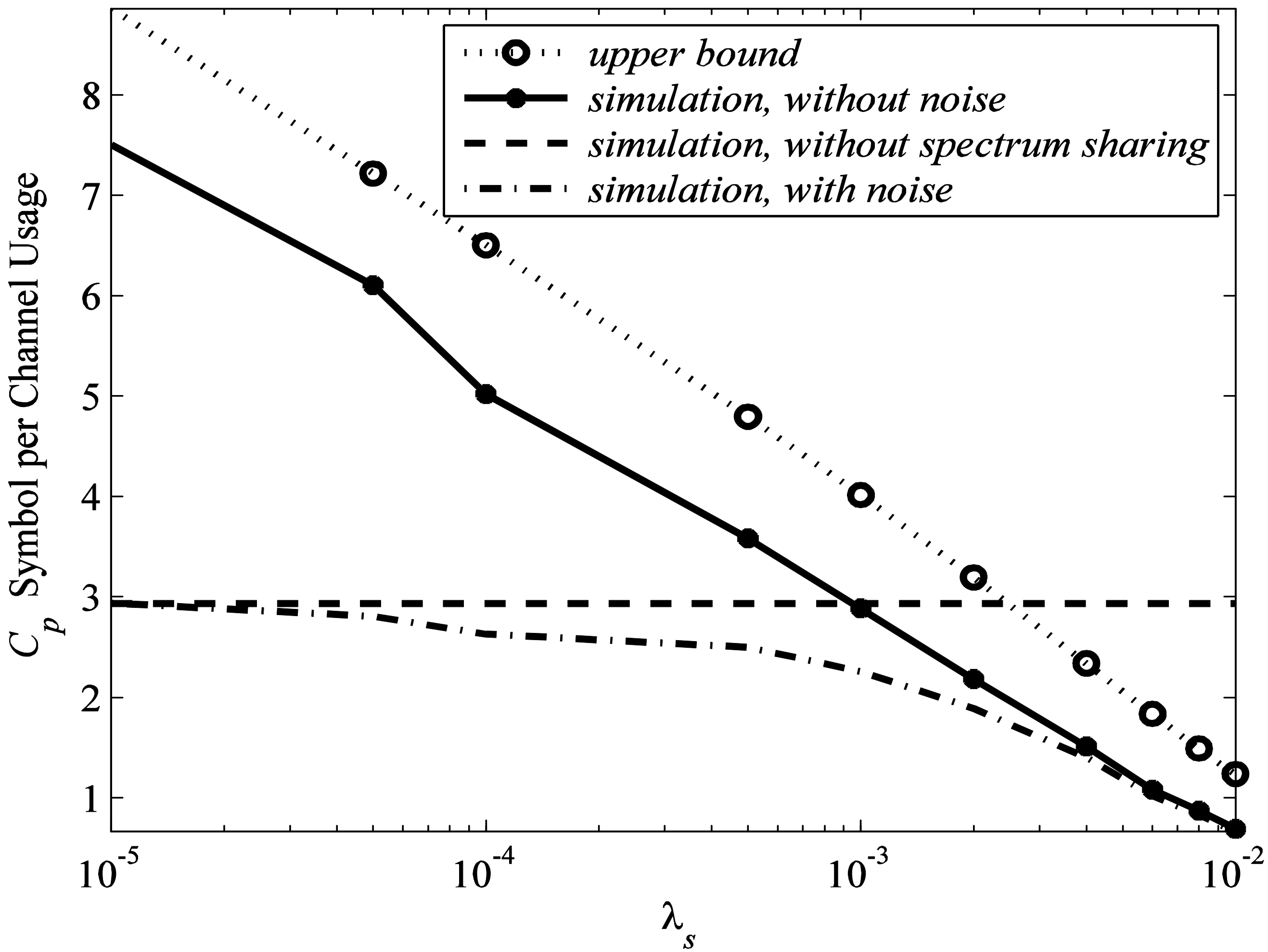
Primary Service Capacity

- The primary service capacity by ignoring the effect of AWGN

$$C_p = \frac{1}{2} E \log\left(1 + SINR_p\right)$$

$$\leq \frac{1}{2} \log\left(1 + \frac{S_p}{S_s}\left(\lambda L R^2\right)^{-\alpha/2} \Gamma\left(\alpha/2+1\right)\right)$$

Primary Service Capacity: Analysis and Simulations



Conclusion

- A closed-form expression was derived for the primary service outage probability in Rayleigh fading environment
- The maximum secondary service transmitter density was obtained to satisfying the primary service outage constraint
- The primary service capacity was analyzed and an upper bound was derived

Thanks!

Mohammad G. Khoshkholgh,
khoshkholgh@modares.ac.ir

Keivan Navaie
keivan.navaie@ieee.org

Halim Yanikomeroglu
halim@sce.carleton.ca