APECE-302: Radio & Television Engineering

Applied Physics, Electronics & Communication Engineering

Lecture # 02

University of Dhaka | APECE DU

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Contents

- Spectrum Allocation
- Theory of Radio Communication Channels
  - Radio Signal Propagation
    - Free-space propagation model
    - Reflection, diffraction, and scattering
  - Fading Channel Models
    - Rayleigh fading
    - Rican fading
    - Nakagami-m fading
    - Log-normal fading

Spectrum Allocation

- FCC, OSM: Office of spectral management (OSM), BTCL, ITU, ETSI
- Spectral auctions?
- License and unlicensed spectrum
- Spectral underlay system: UWB
- Cognitive Radio

Existing Licensed spectrum

AM Radio	535-1605 KHz
FM Radio	88-108 MHz
Broadcast TV (Channels 2-6)	54-88 MHz
Broadcast TV (Channels 7-13)	174-216 MHz
Broadcast TV (UHF)	470-806 MHz
3G Broadband Wireless	746-764 MHz, 776-794 MHz
3G Broadband Wireless	1.7-1.85 MHz, 2.5-2.69 MHz
1G and 2G Digital Cellular Phones	806-902 MHz
Personal Communications Service (2G Cell Phones)	1.85-1.99 GHz
Wireless Communications Service	2.305-2.32 GHz, 2.345-2.36 GHz
Satellite Digital Radio	2.32-2.325 GHz
Multichannel Multipoint Distribution Service (MMDS)	2.15-2.68 GHz
Digital Broadcast Satellite (Satellite TV)	12.2-12.7 GHz
Local Multipoint Distribution Service (LMDS)	27.5-29.5 GHz, 31-31.3 GHz
Fixed Wireless Services	38.6-40 GHz

Unlicensed spectrum

ISM Band I (Cordless phones, 1G WLANs)	902-928 MHz
ISM Band II (Bluetooth, 802.11b WLANs)	2.4-2.4835 GHz
ISM Band III (Wireless PBX)	5.725-5.85 GHz
NII Band I (Indoor systems, 802.11a WLANs)	5.15-5.25 GHz
NII Band II (short outdoor and campus applications)	5.25-5.35 GHz
NII Band III (long outdoor and point-to-point links)	5.725-5.825 GHz

Unlicensed National Info Infrastructure

MICS- Medical implant comm service (401-406 MHz)

Theory of Radio Communication Channel

- Not only noise and external interference
- Radio Signal Propagation
  - Free-space propagation model (SAT, MICRO, Deep Space)

$$P_r(d) = \frac{P_t G_t G_r \lambda^2}{16\pi^2 d^2 L}$$

→ *Loss Factor:* Tx line, filter attenuation, antenna loss

$$G = \frac{4\pi A_e}{\lambda^2}$$

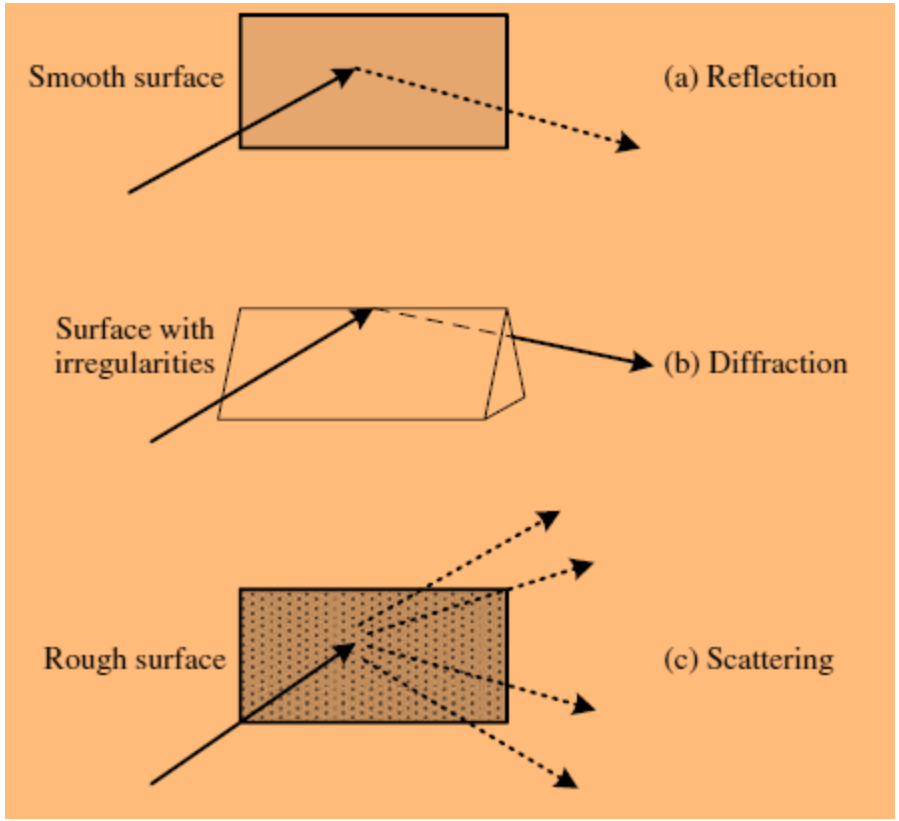
→ Effective aperture

↑ Effective size of the antenna

$$\lambda = \frac{c}{f} = \frac{2\pi c}{\omega_c}$$

Power of d?

Reflection, Diffraction, Scatering



Fading Channel Models

- Amplitude, phase or both
- Coherent and non-coherent Rx
- Local & Global point of view: Complex Gaussian distribution
- Rayleigh fading

rms value of Rx signal

Avg power of Rx fading sig

$$f_{Rayleigh}(r) = \frac{r}{\sigma^2} e^{\left(-\frac{r^2}{2\sigma^2}\right)} \qquad (0 \le r < \infty)$$

Amplitude

$$f_{Uniform}(\theta) = \frac{1}{2\pi} \qquad (0 \le \theta \le 2\pi)$$

Phase

Fading Channel

- Rician

$$f_{Rician}(r) = \frac{r}{\sigma^2} e^{-\frac{r^2+A^2}{2\sigma^2}} I_0\left(\frac{Ar}{\sigma^2}\right) \qquad (0 \le r < \infty,\ 0 \le A < \infty)$$

Peak envelope level of dominant LOS component

Phase?

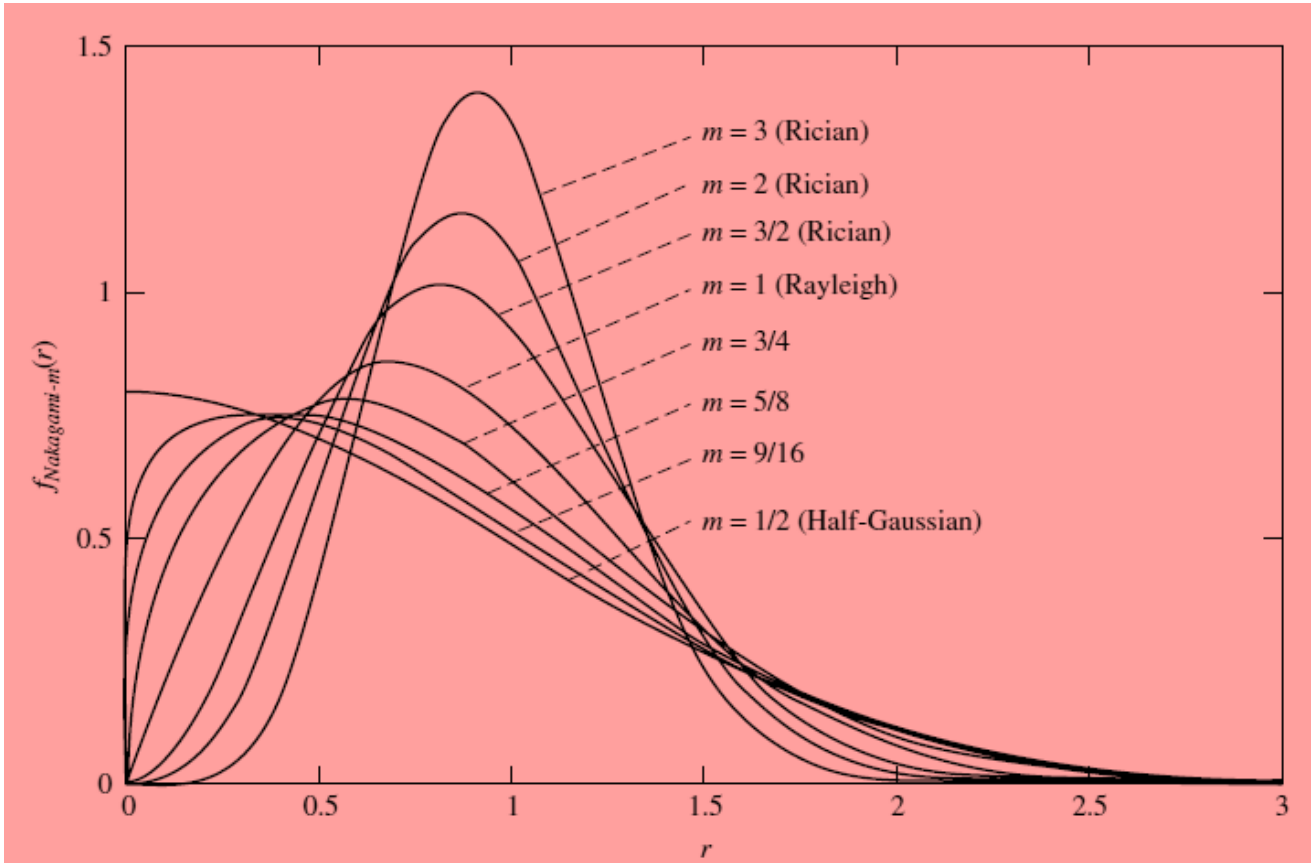
- Nakagami-m fading; m=1/2, m=1, m=infinity?
  - Amount of fading (AF) or fading figure

$$AF = \frac{var(r^2)}{\{E[r^2]\}^2} = \frac{E[(r^2 - 2\sigma^2)^2]}{4\sigma^2}$$

$$f_{Nakagami\text{-}m}(r) = \frac{2r^{2m-1}}{\Gamma(m)\Omega^m} e^{-\frac{r^2}{\Omega}} \qquad (0 \le r < \infty)$$

where $\Gamma(\cdot)$ is the Gamma function, $\Omega = \frac{r^2}{m}$ with r^2 being the average received signal power and m representing the inverse normalized variance r^2, which has to satisfy the condition of $m \ge \frac{1}{2}$,

Fading Channel



Fading Channel

- Log-normal fading

$$f_{log\text{-}normal}(r) = \frac{1}{r\sqrt{2\pi\sigma^2}} e^{-\frac{(\ln r-\mu)^2}{2\sigma^2}} \qquad (0 \le r < \infty)$$

Normal?

$$f^{(dB)}_{log\text{-}normal}(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-\mu)^2}{2\sigma^2}} \qquad (0 \le x < \infty)$$

Q & A