1 Channel Capacity

1.1 ALOHA

$$P(k \text{ transm. in } 2X\text{s}) = \frac{(2G)^k}{k!} e^{-2G} \quad (1)$$

$$S = G \cdot P(0) = Ge^{-2G} \quad (2)$$

1.2 Slotted ALOHA

Probability of k packets generated during a slot:

$$P(k) = \frac{G^k e^{-G}}{k!} \quad (3)$$

Throughput:

$$P(1) = Ge^{-G} \quad (4)$$

1.3 CSMA

Non-persistent If channel is busy, directly run back off algorithm

p-persistent If it is busy, they persist with sensing until the channel becomes idle. If it is idle:
- With probability p, the station transmits its packet
- With probability $1-p$, the station waits for a random time and senses again

2 WLAN & Security Requirements

Confidentiality, Authenticity, Replay Detection, Integrity, Access Control,Jamming Protection

3 DOMINO

Cheating Method	Detection Test
Frame scrambling	Number of retransmissions
Oversized NAV1	Comparison of the declared and actual NAV values
Transmission before DIFS	Comparison of the idle time after the last ACK with DIFS
Backoff manipulation	Actual Backoff/ Consecutive Backoff
Frame scrambling with MAC forging	Periodic dummy frame injection

4 Bianchi

4.1 probabilities

π, probability of transmission, p, probability of collision, $b_{i,k}$ stationary probability of state i, k:

$$\begin{aligned}
p &= 1 - (1-\pi)^{N-1} \\
\pi &= \frac{2}{1 + W_{\min} + pW_{\min} \sum_{k=0}^{m-1} (2p)^k} \\
b_{i,k} &= \frac{CW_i - k}{CW_i} \cdot \begin{cases} (1-p) \sum_{j=0}^{m} b_{j,0} & i = 0 \\ p \cdot b_{i-1,0} & 0 < i < m \\ p \cdot (b_{m-1,0} + b_{m,0}) & i = m \end{cases}
\end{aligned}$$

4.2 Saturation throughput

$$\begin{aligned}
\tau &= \frac{E[\text{Payload Transmitted by user i in a slot time}]}{E[\text{Duration of slot time}]} \\
&= \frac{P_\text{s} P_\text{tr} L}{P_\text{s} P_\text{tr} T_\text{s} + P_\text{tr}(1-P_\text{s}) T_\text{c} + (1-P_\text{tr}) T_\text{id}}, \\
P_\text{s} &= \frac{N\pi(1-\pi)^{N-1}}{1-(1-\pi)^N}, \\
P_\text{tr} &= 1 - (1-\pi)^N, \\
T_\text{s} &= t_\text{header} + t_\text{payload} + \text{SIFS} + t_\text{ACK} + \text{DIFS} + \sigma, \\
T_\text{c} &= t_\text{header} + t_\text{payload} + \text{SIFS} + \sigma
\end{aligned}$$

TODO : Times, and the Bianchi model's equation.

5 Privacy Metrics

5.1 Entropy-Based Anonymity

A the anonymity set, p_x the probability for an external observer that the action was performed by x:

$$\sum_{\forall x \in A} p_x \log(p_x) \quad (5)$$

5.2 Entropy-Based Unlinkability

I_1, I_2, sets of elements to be related, p_r, the probability two elements are related for an external observator:

$$\sum_{\forall R \subseteq I_1 \times I_2} p_r \log(p_r) \quad (6)$$

6 TODO: RFID STUFF

7 TODO: LOCATION PRIVACY STUFF

8 TODO: TCP setups in mobile networks

9 Trunk dimensioning

For a trunk of N channels, an offered load $A = \lambda E[X]$, X the call duration, Y the call arrival per sec $\sim$ Poisson(λ)

$$\begin{aligned}
P_\text{Blocking} &= P(\text{Drop a call because busy line}) \\
&= \frac{A^N}{N! \sum_{i=0}^{N} (\frac{A^i}{i!})}
\end{aligned}$$

Each channel carries the traffic

$$\rho = \frac{(1 - P_\text{blocking})A}{N} \quad (7)$$

Cellular efficiency $E = \frac{Conversations}{cells \times MHz}$

10 Cellular Geometry: Hexagons

Area: $A = 1.5R^2\sqrt{3}$
Distance btw. adjacent cells: $d = \sqrt{3}R$

10.1 Co-channel interference

Co-channel reuse ratio : $Q = \frac{D}{R} = \sqrt{3N}$ with D the **distance** to the nearest co-channel cell, R the **radius** of a cell and N the **cluster size**.

Signal to Interference ratio (SIR) : $\text{SIR} = \frac{S}{I} = \frac{S}{\sum {i_0}_{i=1} I_i}$. With S the desired signal **power**, I_i the **interference power** from the ith interfering co-channel base-station, i_0 the **number of co-channel** interfering cells.

Average received power P_r : $P_r = P_0(\frac{d}{d_0})^{-\alpha}$ or $P_r(\text{dBm}) = P_0(\text{dBm}) - 10\alpha\log(\frac{d}{d_0})$ with P_0 the power received from a small distance d_0 from the transmitter and α the path loss exponent.

SIR in the corner of a cell : $\frac{S}{I} = \frac{R^{-\alpha}}{\sum_{i=1}^{i_0} D_i^{-\alpha}}$

First interfering layer approximation : $\frac{S}{I} = \frac{(\frac{D}{R})^\alpha}{i_0} = \frac{(\sqrt{3N})^\alpha}{i_0}$

10.2 Capacity of a cellular network

For B_t the total allocated spectrum and B_c the channel bandwidth:

$$m = \frac{B_t}{B_c\frac{Q^2}{3}} = \frac{B_t}{B_c\left(\frac{6}{3^{\frac{\alpha}{2}}}\left(\frac{S}{I}\right)_{\min}\right)^{\frac{2}{\alpha}}}$$

10.3 CDMA Capacity: single cell case

For the bitrate R, available bandwidth W, noise spectral density N_0, thermal noise η, received user signal (at base station) S, we have a possible number N of users:

$$N = 1 + \frac{W/R}{E_b/N_0} - (\frac{\eta}{S})$$

10.4 CDMA multiple cells

Frequency reuse factor on the uplink $f = \frac{N_0}{N_0 + \sum_i U_i N_{ai}}$ where N_0 = total interference power received from $N-1$ in-cell users, U_i = number of users in thei^th adjacent cell and N_{ai} = average interference power from a user located in the i^th adjacent cell

Average received power from users in adjacent cell $N_{ai} = \sum_j N_{ij}/U_i$ where N_{ij} = power received at the base station of interest from the j^th user in the i^th cell

11 Antennas & Propagation

Free space propagation, received power: $P_\text{R} = P_\text{T}\frac{A_\text{R}}{4\pi d^2}\eta_\text{R}$ with η_R an efficiency parameter, A_R the receiving antenna area.
Focusing capability, depends on size in wavelength λ:
$G_\text{T} = 4\pi\eta_\text{T}A_\text{T}/\lambda^2$
Directional emitter, received power: $P_\text{R} = P_\text{T}G_\text{T}\frac{A_\text{R}}{4\pi d^2}\eta_\text{R}$
Free space received power: $P_\text{R} = P_\text{T}G_\text{T}G_\text{R}(\frac{\lambda}{4\pi d})^2$
Loss: $L = \frac{P_T}{P_R} = \frac{(4\pi d)^2}{G_R G_T \lambda^2}$
$c = 3 \cdot 10^8$
Parabola: $G = \frac{7A}{\lambda^2}$

11.1 Propagation modes

Ground Wave : $f \leq 2$ Mhz **Line of Sight** : $f \geq 30$ Mhz

Sky Wave

11.2 Line of sight equations

Horizon distance d[km] in **kilometers**, antenna height h[m] and refraction adjustment factor $K = 4/3$:

Optical LOS : $d = 3.57\sqrt{h}$

Effective LOS : $d = 3.57\sqrt{Kh}$

Max LOS distance for two antennas : $3.57(\sqrt{Kh_1} + \sqrt{Kh_2})$

12 Mobnet Decibels

$B = 10\log(\frac{P}{P_0})$

13 Noise

Thermal Noise $N_0 = kT \quad (W/Hz)$
For signal power S, bitrate R, $k = 1.3806 \cdot 10^{-23} JK^{-1}$ the Boltzmann constant and T the temperature: $\frac{E_b}{N_0} = \frac{S/R}{N_0} = \frac{S}{kTR}$

14 Free Space Loss

Free space loss, ideal isotropic antenna:

$$\frac{P_t}{P_r} = \frac{(4\pi d)^2}{\lambda^2} = \frac{(4\pi f d)^2}{c^2}$$

Free space loss equation can be recast:

$$L_{DB} = 10\log\frac{P_t}{P_r} = 20\log(f) + 20\log(d) - 147.56dB$$

Free space loss accounting for gain of other antennas:

$$\frac{P_t}{P_r} = \frac{(4\pi d)^2}{G_r G_t \lambda^2} = \frac{(cd)^2}{f^2 A_r A_t}$$

G_t = gain of transmitting antenna
A_r = effective area of receiving antenna