KFUPM - COMPUTER ENGINEERING DEPARTMENT

COE-543 – Mobile Computing and Wireless Networking

Assignment 2 – Due June 7th, 2009.

Problem 1: (20 points) HSPA is an extension to UMTS 3G system to provide broadband data services. It can be considered as a system which is integrating data services on top of a voice oriented network.

(a) Summarize the capabilities of HSPA in terms of provided bits rates and services.

(b) Explain briefly the medium access protocol supported by HSPA that allows a terminal to transmit and receive data using this system.

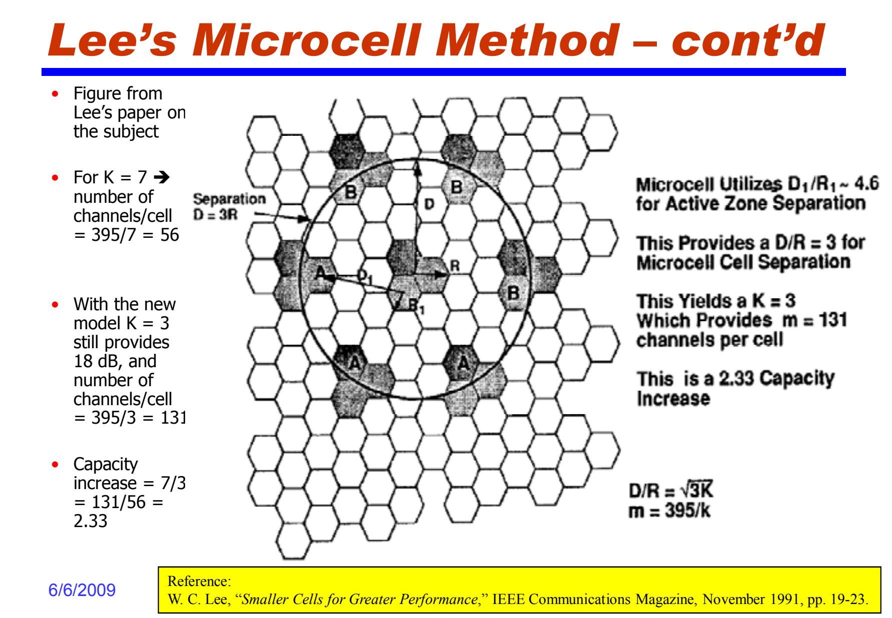
Problem 2: (20 points) Mobile WiMax is a system designed with broadband data as the core requirement. However, there are examples where operators are trying to utilize Mobile WiMAX for providing voice services.

(a) Cite some of these examples by providing a title, a few lines description, and the url (reference) for each of the examples.

(b) What is the medium access protocol within Mobile WiMAX that would be used to provide voice service? Explain.

Problem 3: (20 points) Explain *briefly* how can Lee's Microcell Zone technique provides capacity enhancement for cellular deployments.

Refer to slide 36 of the Cellular Concept Package.



Problem 4.7:

(a) Probability that none of lines are available

From (4.6): $B\,(N,\,\rho)=\dfrac{\rho^N/N!}{\sum_{i=0}^{N}\rho^i/i!}$

$\lambda = 0.5\,(call/hour)\times 100\,(passengers) = 50\,(calls/hour)$ = *50/60 (calls/mn)*

$\mu = 1\,(call)/3\,(mn) = \dfrac{1}{3}\,(call/mn)$

and $\rho=\dfrac{\lambda}{\mu}=\dfrac{50}{20}=$ 2.5

For N = 6, and ρ = 2.5, we have *B(6, 2.5)* = 0.0282

(b) Average delay for accessing the line

From (4.7): $P\left[delay>0\right]=\dfrac{\rho^N}{\rho^N+N!\left(1-\dfrac{\rho}{N}\right)\sum_{k=0}^{N-1}\dfrac{\rho^k}{k!}}$

From (4.9): $D=P\left[delay>0\right]\dfrac{1}{\mu(N-\rho)}$

For N = 6, and ρ = 2.5, we have *P[delay > 0]* = 0.0474
and with μ = 1/3, we have D = 2.44 seconds

(c) Probability of waiting more than 3 mn to access the line
From 4.8: $P\left[delay>t\right]=P\left[delay>0\right]e^{-(N-\rho)\mu t}$
For N = 6, ρ = 2.5, μ = 1/3 and *P[delay > 0]* = , we have *P[delay > 3mn]* = 0.0014

(d) Average delay for accessing the line for 200 passengers rather than 100 passengers
Using (4.7) and (4.9) again, N remaining at 6, but with doubling to 5, we have *P[delay > 0]* = 0.58752, and with μ = 1/3, we have D = 105.753 seconds

Problem 4.8:

(a) Throughput versus offered traffic equation and maximum throughput in Erlang
$S = G\,e^{-G}$ (slotted ALOHA)
and $\dfrac{\partial S}{\partial G}=e^{-G}-Ge^{-G}$ is equal to 0 for G = 1, so that the maximum throughput is equal to $S_{\max}=1\,e^{-1}=$ 0.36 Erlang

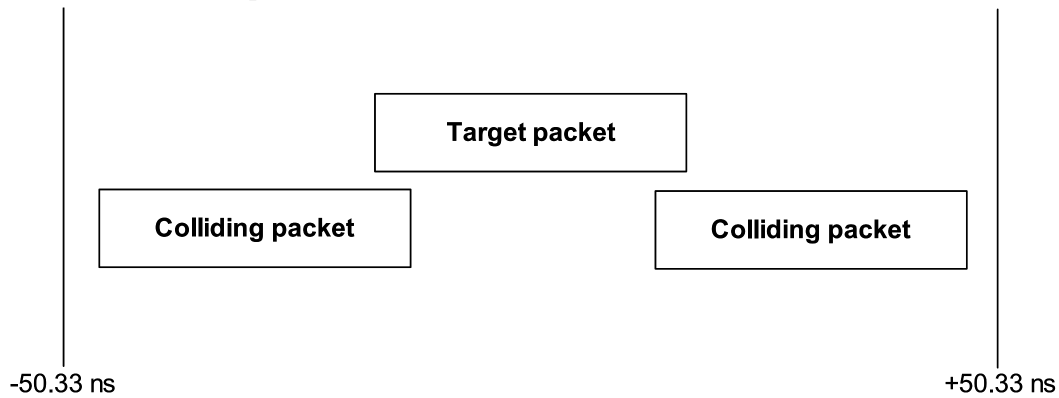
(b) Maximum throughput in bits per second
S_{bps} = 0.36 x 2 Mbps = 720 kbps

(c) Maximum throughput in bits per second for each terminal
If all 50 terminals work simultaneously, $S_{bps/terminal}$ = 720 kbps / 50 = 14.4 kbps
If only one terminal works $S_{bps/terminal}$ = 720 kbps
Therefore 14.4 kbps < $S_{bps/terminal}$ < 720 kbps

Problem 4.11:

Propagation delay = $\frac{0.1\,km}{300{,}000\,km/s} = 0.33$ microseconds

Packet length = $\frac{100\,bits}{2\,Mbps} = 50$ microseconds



The packets are produced according to the Poisson distribution

$$P(K) = \frac{\lambda^K}{K!} e^{-\lambda T}$$

With in our case, λ = 10 packets/seconds, and T = 2 x 50.33 microseconds = 100.66 microseconds
The probability of having no transmission from the other terminals is given by

$$P(0) = e^{-\lambda T} = 0.99899$$

and represents the probability of successful transmission

Problem 5.2:

(a) Required C/I for a bandwidth decrease of 2

The C/I will increase 4 times or 6 dB for dividing the band in two

$$\left(\frac{C}{I}\right)_{dB} = 18 + 6 = 24 \text{ dB}$$

(b) Required frequency reuse factor N for the 15 kHz system

From Equation (5.7): $S_r = 1.76 + 20\log N$

And for S_r = 24 dB, N = 12.94, and the closest higher integer fitting i + ij + j is N = 13. Also see Figure 5.10

(c) Maximum number of simultaneous users

In each cell, we have $\frac{12.5\ MHz}{15\ kHz} = 833$ users with 30 antennas and a frequency reuse of 13.

Therefore the total number of channels will be $\frac{833\ (channels)}{13\ (cells)} \times 30\ (cells) = 1{,}922$ simultaneous users.

(d) For a bandwidth of 30 KHz, we have $\frac{12.5\ MHz}{30\ kHz} = 416$ channels and

$\frac{416\ (channels)}{7\ (cells)} \times 30\ (cells) = 1{,}782$ simultaneous users

Note that the number of simultaneous users in (c) and (d) are close but the quality of service for the 30 KHz system is much better.

Problem 5.3

(a) Number of channels per cell = 500 / 7 = 71

Total number of channels available to the provider = 71 x 100 = 7100

Minimum carrier-to-interference ratio with frequency reuse factor N = 7

$$\left(\frac{C}{I}\right)_{dB} = 10\ \log\left[\frac{1}{6}\left(\frac{D}{R}\right)^4\right] = 10\ \log\left[\frac{1}{6}\left(\sqrt{3N}\right)^4\right] = 18.7 \text{ dB}$$

(b) Number of cells assigned to inner and outer cells

$\frac{D_0}{R_0} = \sqrt{3\times 7} = 4.6 = \frac{D_1}{R_1}$ and $D_1 = 3\ R_0$ so that $\frac{3R_0}{R_1} = 4.6$ and $R_0 = 1.53\ R_1$

$Area = K\ R^2$ and $\frac{A_0}{A_1} = \frac{KR_0^2}{KR_1^2} = (1.53)^2 \quad and \quad A_1 = 0.43\ A_0$

If X is the number of channels, then

$3\,(0.43\ X) + 7\,(0.57X) = 500 \quad and \quad X = 94.7$

For the inner cells: 0.43 X = 0.43 (94.7) = 40 channels

For the outer cells: 0.57 X = 0.57 (94.7) = 54 channels