CDMA up-link capacity

The signal to interference ratio after despreading must be higher than the target signal to interference ratio giving desired bit error rate

$$\frac{GP_{rx}}{\underbrace{\sum_{\substack{j=1 \\ j\neq i}}^{N} \rho_j P_{rx}}_{\text{own cell interference}} + \underbrace{\sum_{k=1}^{M}\sum_{l=1}^{N_k} \rho_{k,l} P_{rx,k,l}}_{\text{other cell interference}} + P_n} = \left(\frac{E_b}{I_o}\right) = \gamma_i \geq \left(\frac{E_b}{I_o}\right)_{target} = \gamma_o$$

If only a single rate service is considered, and the other cell interference is expressed as a fraction of the own cell interference the above expression simplifies to

$$\frac{GP_{rx}}{\rho(1+f)(N-1)P_{rx} + P_n} = \frac{G}{\rho(1+f)(N-1) + 1/\gamma_{rf}} = \gamma_i \geq \gamma_o$$

- G is the processing gain (spreading factor)
- P_{rx} is the power received in the serving base station from user i
- $P_{rx,k,l}$ is the power received in the serving base station for user i from the interfering user l in cell k
- P_n is the receiver input noise power
- $\rho, \rho_j, \rho_{k,l}$ are channel activity factors, averaged and individual
- M is the number of interfering cells
- N_k is the number of active users in cell k
- N is the number of active users in the considered cell
- f is the other to home cell interference ratio, which depends on user spatial distribution and path loss exponent
- $\gamma_{rf} = P_{rx} / P_n$ is the signal to noise ratio in the considered receiver
- $\left(\frac{E_b}{I_o}\right) = \gamma_i, \left(\frac{E_b}{I_o}\right)_{target} = \gamma_o$ are the actual signal to disturbance ratio and the signal to disturbance ratio giving desired BER-level, respectively
- perfect power control
- uniform user spatial distribution in each cell

Now the average maximum number of active users in the up-link is

$$N = \frac{1}{(1+f)}\left[\frac{G}{\rho\gamma_o} - \frac{1}{\rho\gamma_{rf}}\right] + 1$$

Example

- **Processing gain $G = 256$**
- **Channel activity factor $\rho = 0.5$**
- **Other cell interference to own cell interference power ratio $f = 0.6$**
- **Signal to noise ratio: i) $\gamma_{RF} = 10$ (10 dB) , ii) $\gamma_{RF} = 0.1$ (−10 dB)**
- **$\left(E_b/N_o\right)_{target} = 3.16$ (5 dB)**

i) $$N = \frac{1}{1.6}\left[\frac{256}{0.5 \cdot 3.16} - \frac{1}{0.5 \cdot 10}\right] + 1 = 101.14 + 1 = 102.14 \rightarrow 102$$

ii) $$N = \frac{1}{1.6}\left[\frac{256}{0.5 \cdot 3.16} - \frac{1}{0.5 \cdot 0.1}\right] + 1 = 88.77 + 1 = 89.77 \rightarrow 89$$