Wireless PHY/MAC Fundamentals

Subject: 10 (Multiple Access Capacity)
Date: Monday, November 14
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Exercises

a) Consider equ. (3) and (4) in the Hammuda paper, for orthogonal and non-orthogonal (CDMA) multiple access. Answer the following questions:

1) Verify by (mathematical) arguments that orthogonal single cell capacity is larger than non-orthogonal single cell capacity, i.e. confirm the author's statement for $S > 0$.
Hint: Consider the limiting case for M (equality) and justify, using the log inequality

$$\frac{x}{1+x} < \ln(1+x) < x, x \neq 0, -1 < x$$

that at the limit, a larger M will make the condition true for $S > 0$.
You may also try to *justify* the general case, for all $M > 1$, using the same log inequality, although this is somewhat more difficult to prove for all $S > 0$.

2) Evaluate the expressions for the case of SNR equal to 3 and 20 dB (remark, signal to *thermal* noise ratio) and plot the results on one or two graphs showing log-capacity in bps/Hz versus no. of users (channels) M.
Hint: First, reformulate the expressions in terms of the SNR.

What can you conclude on the capacity (spectral efficiency) between the orthogonal and non-orthogonal multiple access? What happens when the SNR is changing?

3) Considering now that the orthogonal system needs to apply a cell frequency reuse factor of 7 for the system to work, whereas the non-orthogonal will work with a reuse of 1 (the cell reuse is a concept you will come to explore in more detail later, but generally this is needed to provide adequate service in a system consisting of multiple cells; the implication is that the non-orthogonal system can use the full assigned spectrum in every cell, whereas the orthogonal can use only 1 part in 7 of the spectrum in every cell).

Modify the equations to take this aspect into account, and redo b). What do you conclude on the multi-cell (system) spectral efficiency?