Agenda item:	
Source:	Lucent Technologies
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1. INTRODUCTION

Recent contributions have investigated the performance of multiple antenna architectures for HSDPA [1][2]. In particular, an architecture called 'code re-use' uses each spreading code to modulate multiple distinct data substreams. These substreams are simultaneously transmitted from multiple antennas, and the receiver uses multiple antennas to distinguish the signals based on spatial characterstics. Preliminary link level simulations indicate significant performance gains over a conventional single antenna architecture and the space-time transmit diversity (STTD) technique.

In this contribution, we discuss some practical implications of the multiple antenna architecture with code re-use. We address antenna spacing issues at the terminal and base station, backward compatibility with current HSDPA proposals and UMTS dedicated channels, and complexity issues at the terminal. Following a high level assessment of these potential impediments, we conclude that none of them should prevent further investigations and performance evaluations of the proposed architecture.

2. ANTENNA SPACING

High spectral efficiencies of the code re-use system are achieved when there is uncorrelated fading among pairs of transmitter and receiver antennas. Sufficient spacing among the antennas at both the base station transmitter and terminal receiver are required for uncorrelated fading. At the base station, uncorrelated fading is achieved using a separation of 10 wavelengths between nearest neighbors in a linear base array of dual-polarized antennas [3]. It is also shown that an antenna separation of 4 wavelengths is sufficient to achieve 80% of the capacity. With a 2GHz carrier frequency, the wavelength is 15cm. Hence an array of 4 antennas with 10 wavelength spacing is 4.5m long and with 4 wavelength spacing is 1.8m. Using dual-polarized antennas, four antennas can effectively fit in the space of two unpolarized antennas so that the respective array lengths are only 1.5m and 0.6m. These values are all within the range of current base station antenna configurations.

Because the terminal receiver is at the same level as local scatterers, only 0.5 wavelength antenna spacing is required to achieve uncorrelated fading [3]. An array of 4 antennas with dual-polarization requires only 7.5cm of linear space. High data rate servcies will most likely target terminals with relatively large screens such as personal digital assistants (PDAs) or laptop computers. These devices will have ample surface area to easily support up to 4 antennas.

3. BACKWARD COMPATIBILITY

The proposed code re-use architecture is backward compatible in terms of transmit power requirements, code usage and code orthogonality with exisiting HSDPA proposals. As discussed in [1] and [2], the transmit power is normalized at each antenna so that the total radiated power among all antennas is the same as the power from a conventional single antenna transmitter. One of the main ideas of the code re-use proposal is that the codes are used multiple times to spread distinct data substreams. For example, in a conventional single antenna HSDPA system, 20 out of 32 orthogonal spreading codes can be used to spread 20 data substreams. With the code re-use technique and $M = 4$ antennas, the same 20 codes can be used to spread a total of 80 data substreams. The substreams which share a given code are spatially resolved at the receiver using multiple antennas. Code re-use does not introduce additional interference among the 20 codes nor among the remaining 12 orthogonal spreading codes. Hence the code re-use architecture is backward compatible with the UMTS dedicated channels on those 12 codes.

4. TERMINAL COMPLEXITY

A high level investigation on the feasibility of a code re-use receiver for a HSDPA-type system appeared in [4]. The main baseband components are a despreader, a space-time combiner, a detector for eliminating spatial interference, and a turbo decoder. It was shown that the turbo decoder requires the majority of the processing power. For a 2 transmit antenna, 2 receive antenna system, the detector portion accounts for about 5% of the total processing and the turbo decoder accounts for about 87% of the processing. For a 4 transmitter, 4 receiver system, the detector and turbo decoder account for about 20% and 70% respectively of the total processing. Compared to a conventional single antenna receiver for HSDPA which requires about 1.6×10^9 operations per second, the 2 antenna receiver requires 1.7×10^9 operations per second and the 4 antenna receiver requires 2.1×10^9 operations per second. These computational requirements are for a fixed data rate and were estimated assuming brute-force processing techniques but are already within the range of existing hardware technologies. More detailed studies will mostly likely reduce the processing requirements significantly.

5. REFERENCES

[1] Lucent. Enhancements for HSDPA using multiple antennas. TSG_R WG1 document TSGR1#15(00)1096, 22-26th, August 2000, Berlin, Germany.

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