Agenda item: AH24 : High Speed Downlink Packet Data Access

Source: Lucent Technologies

Title: Complexity of Node B for MIMO architectures

Document for: Discussion

1. INTRODUCTION

In previous contributions [1][2], link level results for high speed downlink packet access (HSDPA) demonstrated the gains of multi-input/multi-output (MIMO) transmission and detection techniques compared to conventional single antenna techniques. Contributions [3] and [4] have addressed the complexity of the UE for MIMO architectures. In this contribution, we address the complexity at the Node B for MIMO architectures over those requirements for conventional HSDPA transmission with a single antenna. Specifically, we discuss the additional baseband processing required for MIMO transmission, and the antenna separation requirements for sufficient channel decorrelation.

2. BASEBAND COMPLEXITY

The architecture for transmitting on the DSCH in conventional and MIMO modes are discussed in the Technical Report [5] and repeated here. As shown in Figure 1, for the DSCH with conventional single antenna transmitters, a high data rate source is demultiplexed into N lower rate substreams, and the nth substream ($n = 1 \ldots N$) is spread with spreading code n (where the spreading codes indexed by $n = 1 \ldots N$ are mutually orthogonal). These substreams are summed together, scrambled and transmitted. A multiple antenna transmitter with M antennas is shown in Figure 2. It represents a typical transmitter for the multiple-input multiple-output (MIMO) antenna processing technique. The high data rate source is demultiplexed into MN substreams, and the nth group ($n = 1 \ldots N$) of M substreams is spread by the nth spreading code. The mth substream ($m = 1 \ldots M$) of this group is transmitted over the mth antenna so that the substreams sharing the same code are transmitted over different antennas. These M substreams sharing the same code can be distinguished based on their spatial characteristics at the receiver using multiple antennas and spatial signal processing.

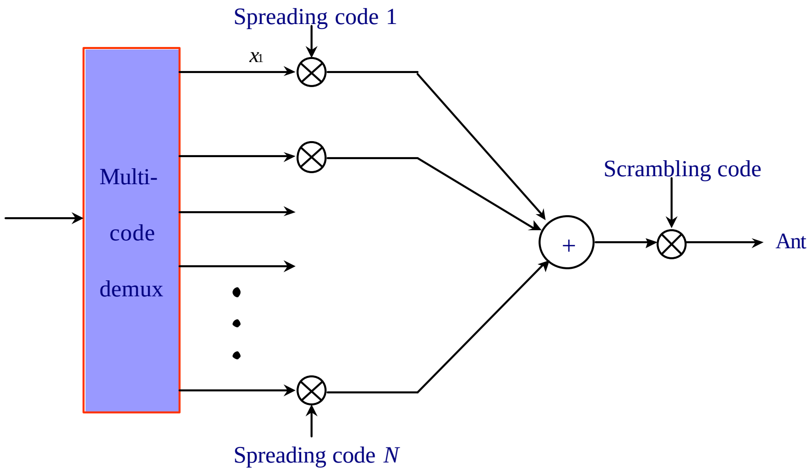

Figure 1. Block diagram for baseband processing of single antenna HSDPA transmission.

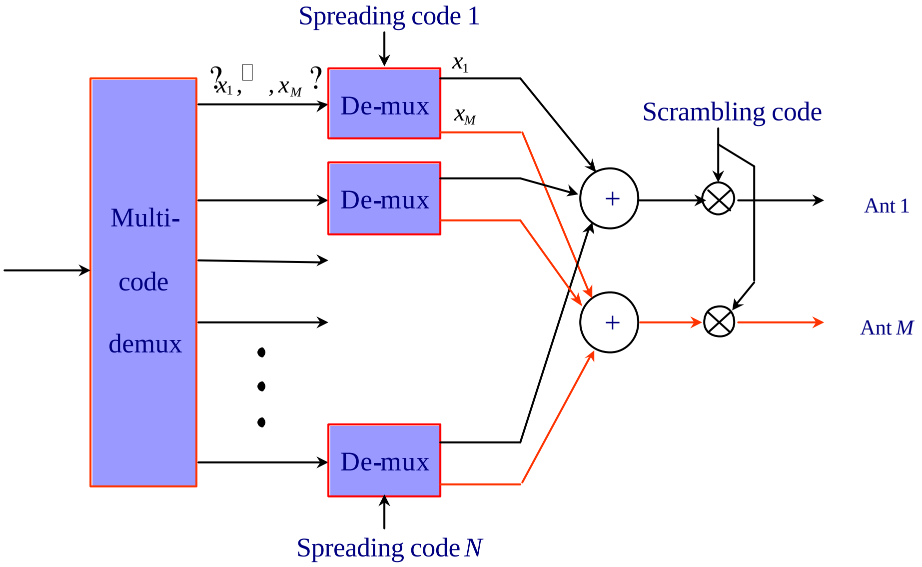

Figure 2. Block diagram for baseband processing of MIMO HSDPA transmission.

In terms of baseband processing, the N demultiplexers in the MIMO system require minimal additional complexity over the single antenna transmitter.

The power of the MIMO transmissions are normalized so that for the DSCH the total transmit power summed across the M antennas is the same as for the single antenna transmission. Non-MIMO transmission on other dedicated channels using other Walsh codes are transmitted over antenna 1. The MIMO and non-MIMO signals will not interfere with each other since the Walsh codes used are mutually orthogonal. Because of the reduced power for antenna in the MIMO system, its peak-to-average power is benficially reduced.

A table showing coding rates and data constellations for a representative set of data rates is shown in Table 1. For a given data rate, MIMO transmission uses smaller constellations, resulting in even better peak-to-average characteristics for each demultiplexed stream.

# of trans-mitters	Tx tech-nique	Code rate	Modu-lation	Data rate per substream	# sub-streams	Total data rate
1	Conv.	¾	64QAM	540Kbps	20	10.8Mbps
2	MIMO	¾	8PSK	270Kbps	40	10.8Mbps
2	MIMO	¾	16QAM	360Kbps	40	14.4Mbps
4	MIMO	~½	QPSK	135Kbps	80	10.8Mbps
4	MIMO	¾	QPSK	180Kbps	80	14.4Mbps
4	MIMO	¾	8PSK	270Kbps	80	21.6Mbps

Table 1. Transmission architectures

3. ANTENNA SEPARATION

Antenna separation at the base station was initially discussed in contribution [3]. In the same way that transmit diversity techniques rely on uncorrelated fading among pairs of transmitter and receiver antennas, high spectral efficiencies of the MIMO system also rely on uncorrelated fading. The correlation depends on the spacing between antennas and height of the antennas with respect to the local scatterers.

For outdoor base stations where the antennas are significantly higher than the scatterers, totally uncorrelated fading is achieved using a separation of 10 wavelengths between nearest neighbors in a linear base array of dual-polarized antennas [6]. It is also shown that an antenna separation of only 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 array lengths are only 1.5m and 0.6m respectively for 10 and 4 wavelength separation. These values are all within the range of current base station antenna configurations and are comparable with separations required for transmit diversity.

For indoor base stations, or in situations where the antennas are at the same height as the local scatterers, the scatterers will cause more decoupling of the signals at the antennas. Hence the required antenna separation for a given level of correlation will be even less.

4. REFERENCES

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[5] 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Physical Layer Aspects of UTRA High Speed Downlink Packet Access; (Release 2000), (3G Technical Report (TR) 25.848, version 0.2.1), Tdoc R1-00-1480, TSG-RAN WG1; January 15th-18th, 2001, Boston, USA.
[6] D. Chizhik, F. Rashid-Farrokhi, J. Ling, A. Lozano, "Effect of antenna separation on the capacity of BLAST in correlated channels," to appear in *IEEE Communications Letters*.